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N = notis. F = foredrag. FR = foredrag, referert.

Side
Bjørlykke, Harald: Gull i Finnmark. F 271
Broch, Olaf Anton: Luftkartleggingen i geologiens tjeneste. F 156
Brøgger, W. C. Bibliografi av W. P. Sommerfeldt .... 199—249
— Minnetaler av V. M. Goldschmidt og O. Holtedahl. F 156
Bugge, Jens: Geological and petrographical investigations in the Arendal District. 15 fig.. 4 t. .... 71—112
— Trekk av Arendalfeltets geologi. FR .... 269—271
Føyn, Sven: Stratigrafiske og geologiske undersøkelser av devonformasjonen på Spitsbergen utført på den engelsk-norsk-svenske Spitsbergen-ekspedisjon 1939. F 277
Gjessing, Leiv: Contribution à l'étude des metasilicates. N .... 265—267
Goldschmidt, V. M.: Brøgger som mineralog og petrograf. F 156
Grorud. Hans Fredrik: Et profil gjennom ogygiaskifer og ampyxkalk på Tørtberg, Frogner ved Oslo, 2 fig. .... 157—160
Grønlie, Ole T.: On the traces of the ice ages in Nordland, Troms, and the south-western part of Finnmark in Northern Norway, 18 fig., 5 t. 1— 70
Heintz, A. Oversikt over fiskefaunaene i Spitsbergens downtonisk-devoniske lagrekker. F 277
Holmsen, Gunnar: Torvlag og steinlag i marin leir ved Grorud stasjon. N 250—253
Holtedahl, Olaf: Brøgger som paleontolog og geolog. F 156
— Luftkartleggingen i geologiens tjeneste. F 156
Holtedahl, Olaf, og Rosenqvist, Ivan: Om fjellbygningen i Opdal—Sunndal-strøket. FR .... 274—277
Isaghsen, Fridtjov: Grefsenmorenenes opbygning og fossilinnhold, 6 fig. N .... 253—262
— Kvartsporfyr i Åros, Røyken, 2 fig. N .... 263—265
Kolderup, Niels Henrik: Bergensbuenes geologi. F 153
Neumann, Henrich, og Rosenqvist, Ivan Th.: On red, fluorescent calcite from the Fen Area near Ulefoss. N .... 267—268
Norsk geologisk forening .... 153—156, 269—277
— Regnskap .... 154—155
— Reuschmedaljen 155
— Revisorer 155
— Styre 155
— Sulitelmafondet 152
— Årsmelding .... 153—154

Side
Notiser .... 250—268
Oftedal, Ivar: Enrichment of lithium in Norwegian cleavelandite-quartz-pegmatites .... 193—198
Rosenqvist, Ivan Th. Se Holtedahl, Olaf, og Rosenqvist, Ivan.
— Se Neumann, Henrich, og Rosenqvist, Ivan Th.
Skappel, Vilhelm: Luftkartleggingen i geologiens tjeneste. F 156
Sommerfeldt, W. P.: W. C. Brøggers liv bibliografisk fremstillet ...... 199—249
Strand, Trygve: Oversikt over fjellbygningen i Nordre Gudbrandsdalen, 1 fig. FR .... 271—274
Strøm, Kaare Münster: Geologisk kartlegging i svart og hvitt. F ... 153
Størmer, Leif: Dictyonema shales outside the Oslo Region, 1 t. ..... 161—170
— Early descriptions of Norwegian trilobites, 4 fig., 3 t. .... 113—151
Vogt, Th.: Bidrag til Spitsbergen-devonens geologi og stratigrafi. F ... 277
— Geological notes on the dictyonema locality and the upper Guldal District in the Trondheim Area, 5 fig., 1 t. .... 171—192

Ms. rec. May 18, 1938.

ON THE TRACES OF THE ICE AGES IN NORDLAND, TROMS, AND THE SOUTH-WESTERN PART OF FINNMARK IN NORTHERN NORWAY

BY

OLE T. GRØNLIE

18 TEKSTFIG. AND 5 PL.

Introduction. In later years several authors have devoted a more or less close study to the quaternary geology of Northern Norway. In the first place are here to be mentioned TANNER 1930 (20) and NORDHAGEN 1933 and 1935 (14 and 15). The present author has also for many years been interested in quaternary geological problems and has in the course of time collected a varied material concerning these matters in that part of our country. On account of duties as a functionary I have had too little time for working out the material collected or the working has been so much retarded that something may have been forgotten and more or less lost when it was to be used. As it is the quaternary conditions of Northern Norway have at present got such an actuality that I find it appropriate to present a part of the material which I have been able to work out, and to take a preliminary view of the said problems.

CONTENTS

Page
I. The Great Ice Age 2
II. The Last Ice Age 11
  1. Stages of the ice border during the melting period 11
  2. The maximal thickness of the last inland ice 20
  3. The evidences of fossils and living plants of a last ice age 25
III. The Late Glacial Shore Lines 27
  1. Some general remarks 27
  2. The shore line diagram 28
  3. Levellings used in the diagram 30
  4. The upper marine boundary 43
  5. The Tromsø — Lyngen stage of the ice front 45
  6. Correlation between Northern Norway and the Oslo District 51
IV. Equations of the Lines in the Shore Line Diagram. The Eustatic Stand of the Sea Level 53
V. Connection between the Depth of a Depression and the Thickness of the Depressing Ice Sheet 59
Norwegian summary 65
Literature 69

I. The Great Ice Age.

I have on former occasions maintained that in Northern Norway only two ice ages can be traced, a great glaciation which covered all or nearly all the land and the continental shelf and a last glaciation of less extent and thickness which filled all valleys and fjords and overflowed the lower mountain parties and a part of the continental shelf. With this I did not mean to say that Northern Norway only once has been totally glaciated. There may have been as many great glaciations as elsewhere known, but the last total glaciation seems to have been so great and has so deeply eroded that every trace of former glaciations have been blotted out and ancient interglacial deposits destroyed. Northern Norway is not, however, so minutely surveyed that it can be denied that traces of glacial erosion or interglacial deposits from a time previous to our great glaciation may be found, but to the present time no such finds have been done.

In the Alps four glaciations have been counted and in Germany three. The great glaciation in Northern Norway is most likely to be correlated with the next but one of these, the Riss glaciation in the Alps and the Saale glaciation in Germany. But apart from the correlation can it be said that the glacial erosion in the mountainous part of our country has, at all events, been so strong that the work must have been done by an ice sheet of great thickness and velocity. All loose material from preglacial times has been taken away and all weathered rock removed. Mountain wilds have been ground and levelled, tops and ridges were rounded, and deep troughs were formed on the bottom of the fjords etc. In short all the leading features of the landforms must be the work of the great total glaciation, either they are to be found in the inner land, on the outermost skerries or on the bottom of the sea.

In the inner land cirques and troughs are very seldom to be found and hardly ever on the eastern or south-eastern side of the mountains which everywhere is a stoss-side. If cirques are to be found they mostly appear within the loftiest mountain parties to which the inland ice did not reach during the last glaciation and therefore were only locally glaciated. All the islands off the coast have a stoss-side to the east or southeast where cirques and deeply eroded trough valleys very seldom are to be found. Hindøy, Andøy, Senja, Kvaløy, and

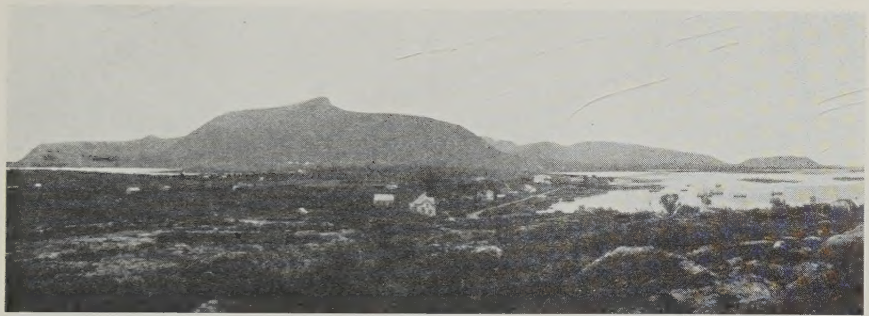

Fig. 1. Profile from east to west of Andøy, seen from Risøyhamn. Gr. phot.

Ringvassøy, and most of the other islands show this trait whether outlaying or near the coast of the mainland. On the west and northwest coast of the islands both cirques and trough valleys are common, but they are of a younger date, distinctly worked out in a land formerly eroded by an inland ice, for the fresh surface of their surrounding walls cuts an old one everywhere. Against the open sea projecting points are often cut by cliffs, the work of the sea in past and present time.

When trying to find out something about the extent and thickness of the ice sheet of the great glaciation the best facts to go upon are the ice worn landforms and the loose material, especially erratic blocks. Fig. 1 shows a cross section of Andøy from east to west along the southern flank of the mountain party north of Bjørnskin chapel. Such a profile cannot have been formed in any other way than by an ice sheet moving from east to west across the island. Other sections across this island prove the same fact. The loose material is a bottom moraine. At lower levels erratic blocks are common, but from about 300 m upwards blocks are not to be seen on the surface which often has been levelled to small flats or plateaus called »heier« by the population. The flowing ice sheet must have had great thickness and velocity, and at higher levels where the ice was relatively clean most of the loose material was successively taken away by the flowing ice. On the western side of the mountains younger local glaciers have cut cirques and troughs into the old ice scratched rocks. Farther to the north most of the islands tell the same story. In the high western part of Senja similar flats have been planed by the ice. The northern part of Kvaløy is a plateau land about 600 m above sea

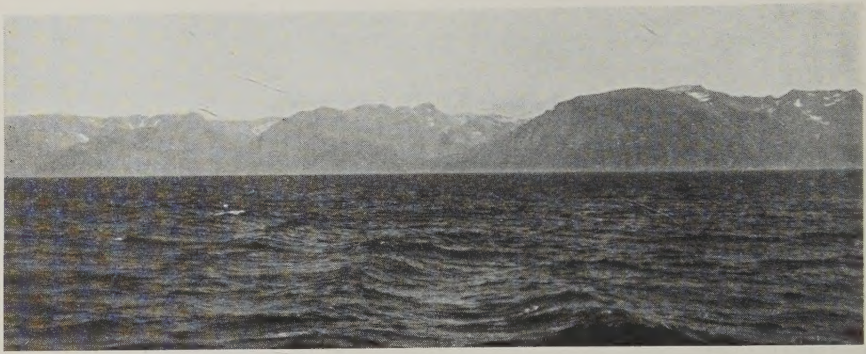

Fig. 2. Seiland in Finnmark, seen from the Sørøy-sound. Gr. phot.

level with a multitude of erratic blocks of foreign rocks. This plateau has once been overflowed by a great Balsfjord glacier. To the west it is cut by the steep walls of cirques and troughs (6) [1]. On Ringvassøy ice worn flats at higher levels are less conspicuous because the southeastern part of this island consists of hard igneous rocks, but the northwestern part is cut by valleys and fjords for a greater part owing to erosion by local glaciers. The southern part of Vanøy is a plateau land, the lofty islands Arnøy and Kågøy have rounded forms and seem to have been overflowed by the ice, at all events Arnøy. Sørøy, Stjernøy, and Seiland are lofty islands with cirques and trough valleys due to a strong local glaciation, but taken as a whole the landforms show that they once must have been overflowed by an inland ice (fig. 2).

The eastern part of Langøy in Vesterålen is strongly worked by the ice, and erratic blocks have been found to about 300 m a. s. l. In the western part of this island mountains rise to 1000 m or more, and some pointed tops are to be seen and may be primary nunataks, but a closer study is necessary to settle this question. Hadseløy is ice worn all over. The eastern side is a stoss-side, and at higher levels erratic blocks have been found to about 450 m, but after the time of the inland ice the north side has been strongly cut by local glaciers. The landforms in the western part of Lofoten islands have been treated by Th. Vogt (22). There are plenty of steep summits and a multitude of cirques cut by local glaciers, but he also found large flats — "heier" — at high levels. Such flats are easily found on

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[1] The numbers in parentheses refer to the list of literature p. 69.

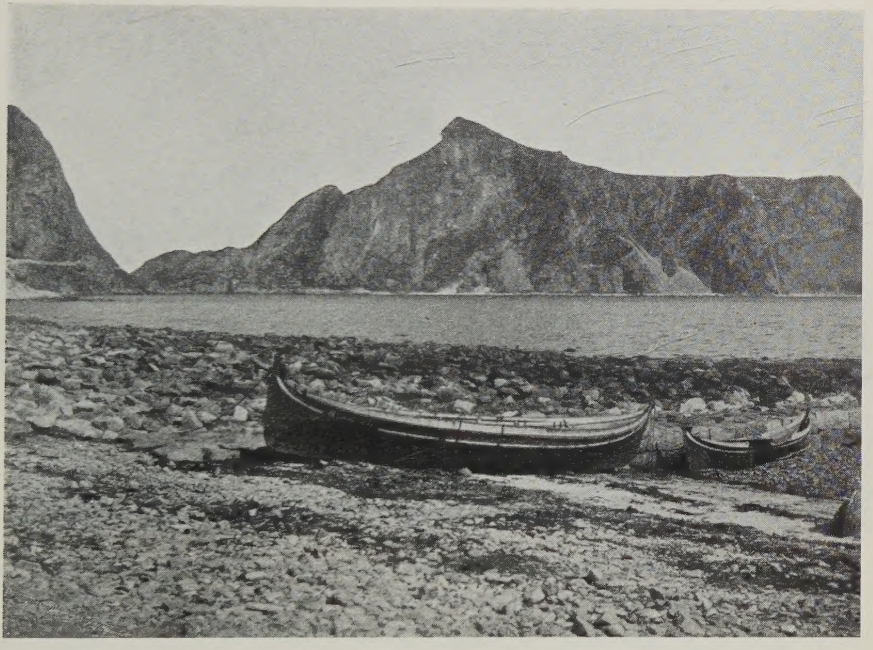

Fig. 3. A mountain formed by the inland ice in the eastern part of Vestvågøy, seen from SW. Riksheim phot.

topographic maps and by studying the outlines of the mountains. Fig. 3 is a mountain in the eastern part of Vestvågøy showing the work of the inland ice. Værøy must once have been overflowed by an inland ice. The eastern side is a stoss-side and the western side is for a greater part a vertical cliff. From a strandflat to the east the mountain side rises rather steeply, but in many places even, to the edge of the cliff. Fig. 4 shows an ice worn ridge with a direction about NE—SW. 450 m above sea level, and fig. 5 shows an erratic block lying close on the edge of the cliff to the west about 400 m a. s. l. This block has no doubt been transported and rounded by the ice, but now it has a thick weathered crust and must therefore have been in its present place for a rather long time. The island seen in the background is Mosken. To the left of the block is seen a square, the uppermost part of a landslip where stones of many foreign rocks have been found. Even Røst farther to the west seems to have been overflowed by an inland ice, for most islands there are flat on top like Vedøy, fig. 6.

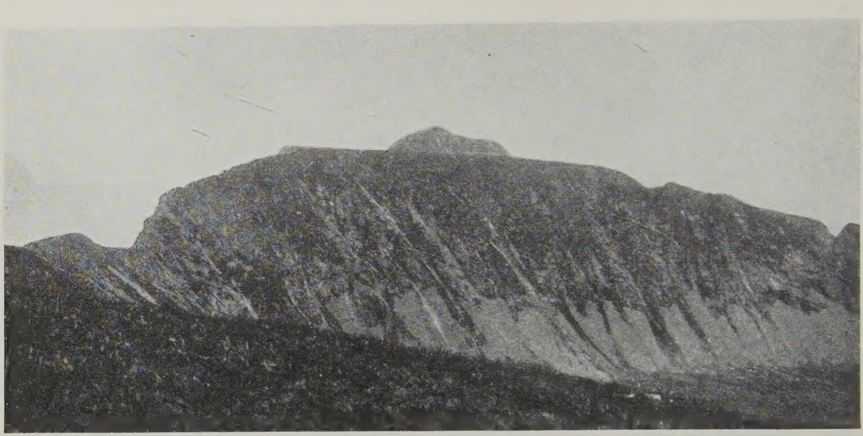

Fig. 4. A mountain ridge formed by the inland ice on Værøy.
Direction NE—SW. Gr. phot.

Vogt did not find erratic blocks on the flats in the western Lofoten, and therefore he could not decide on the time of their forming, if preglacial or glacial, but since erratic blocks have been found on Kvaløy to 600 m a. s. l., on Hadseløy to 450 m, and on Værøy to 400 m there can be no doubt as to the glacial origin of the said flats. Nor is it questionable that the Lofoten islands at a later date have been strongly locally glaciated. It is likely that some of the peaks there are primary nunataks, but no indubitable nunatak has yet been found, nor the uppermost level to which the surface of the inland ice did rise when it had its maximal thickness. 900 to 1000 m above the present sea level may not be too much if taken into consideration that flats to about 800 m a. s. l. have been planed by this ice sheet.

On the mainland the thickness of the ice sheet was much greater, and there is certainly no nunatak from that time to be found. The Tromsdalstind, above 1200 m high, has a rounded top and has no doubt been overflowed by the ice, and such must be the case with the Lyngen peninsula too. Stetind in the Tysfjord district is about 1400 m high (fig. 7), but there is a flat on top, and therefore this top must as well have been fully overflowed by the great ice sheet. Afterwards this summit must also have been nunatak for a long time because of its form. Fig. 8 shows the Børvasstinds to the south of the Skjerstad fjord. These mountain parties have nunatak form, but they have for all that been overflowed during the great ice age. The

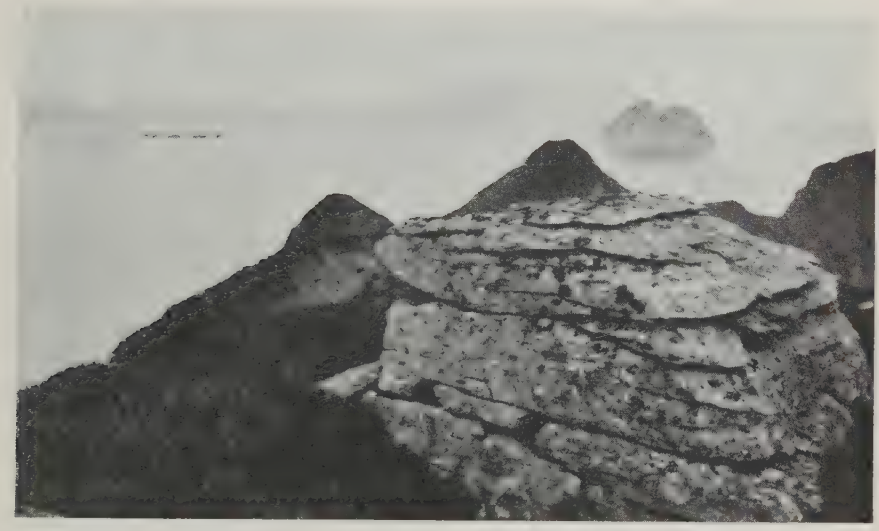

Fig. 5. A weathered erratic block on the top of the western cliff on Værøy 400 m a. s. l. Mosken is seen in the background. Gr. phot.

nunatak form is of a later date. The large peninsula where the Svartis Glacier is situated rises to above 1600 m, but it has, however, been overrun by an ice flow from southeast, for scouring marks have been pointed out to above 1400 m a. s. l. with the direction SE—NW.

In Helgeland the Okstinds on the northern side of lake Røsvatn have the loftiest summits. This mountain party was explored by Hoel in 1908. Besides blocks from lower levels and scouring marks to great heights he also found a block of a red granite between the Oksskolt and Wilhelm II tind 1800 m a. s. l., a foreign rock in this locality. The Oksskolt is the highest summit there, 1912 m, and Hoel is of the opinion that this summit once has been overflowed by the ice.

According to what has been stated above, it must be supposed that the surface of the ice sheet of the great glaciation at the frontier rose to between 1900 and 2000 m above the present sea level in Helgeland, to between 1800 and 1900 m in the Salta district, to between 1700 and 1800 m in Troms fylke and to between 1500 and 1600 m in the southwestern part of Finnmark. If so all the mainland was covered by the ice sheet without a single nunatak rising above the ice, but as the thickness of the ice sheet was decreasing westwards it is likely that some nunataks did rise above the surface in the

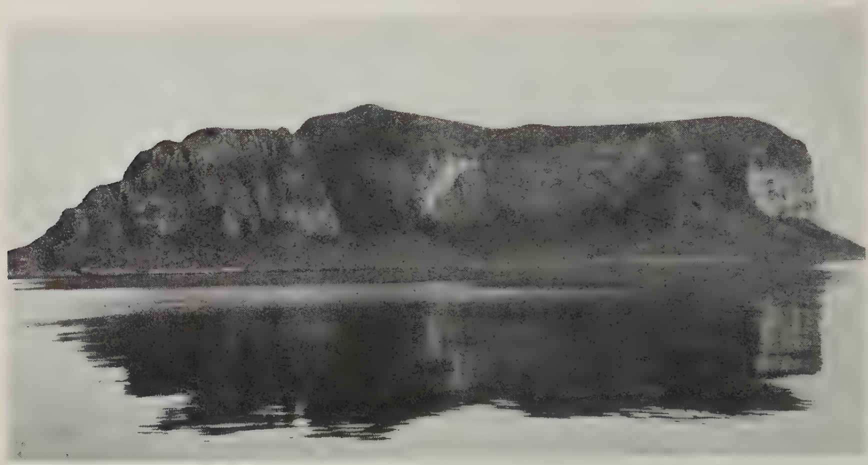

Fig. 6. Vedøy in the Røst group, seen from northeast. Supposed to have been formed by the ice. C. Dons phot.

western parts of the Lofoten islands. However, to locate such nunataks and fix the upper level of the surface of the ice during the maximal stand of the ice sheet may be a troublesome work, and only trained alpinists will be equal to this task.

An ice flow of such dimensions as here supposed would obviously move on across the continental shelf till the ice no longer was in contact with the bottom. Then advanced lobes would be broken off and float away as ice bergs. If at the same time an eustatic sinking of the sea level was greater than the isostatic sinking of the land in the peripheric part of the glaciated area, the depth of the sea would be relatively less than now, and therefore it is likely that calfing did not take place till at the outer border, the edge, of the shelf. It is also likely that the ice had played a part in the forming of the continental shelf. Ice masses pressed out through valleys and fjords no doubt eroded at and off the mouths of the fjords, but farther on the ice streams would unite to a continuous sheet all over the shelf, depositing loose material and levelling the bottom. In 1933 I accompanied C. Dons in the motor cutter "Gunnerus" of Trondheim on a cruise to the west coast of Senja for soundings and dredgings. As the ship was fitted out with a powerful dredging apparatus, rather coarse material could be dredged from the bottom in a series of stations on the Svendsgrunn stretching from Senja westwards to the edge of the

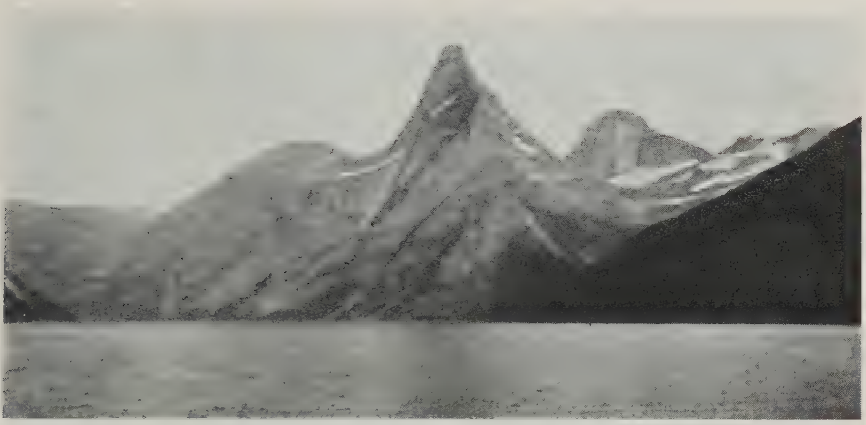

Fig. 7. The Stetind in the Tys-fjord district, about 1400 m high, flat on top and supposed to have been overfloved by the great ice sheet. Gr. phot.

continental shelf. Besides gravel and pebbles boulders to about 30 cubic dm were common everywhere, mostly of igneous rocks. Mica schist and limestone were not to be seen, and of sedimentary rocks only a block of a sandstone has been noted. Dredgings in other places have given similar results. It seems to be a fact that such material is to be found especially on the bottom to leeward of islands high enough to check the lower layers of a moving ice sheet.

Observations of scratchings, stoss-sides, and other forms of ice erosion tend to show that the ice sheet must have moved rather independently of the land surface below if sufficiently thick. If the ice stream crossed the boundary land with a thickness of 1000 m or more valleys and fjords could not settle the drainage. They would soon be filled with ice and moraine material till the whole land was levelled to a plateau slightly dipping to the west and northwest, and over this plateau the ice took a short cut across our country. The eroding work has for the most part been done at high levels, and only where the direction of a valley or a fjord was the same as the direction of the moving ice has the erosion come lower down and in some places reached the bottom and eroded there. Finds of erratic blocks at high levels at a distance of 100 km and more from their homestead show a transport for a long way at high levels. Such a block of swedish granite has been found on the eastern side of the Tromsøysund near Tromsø at about 200 m a. s. l., on Kvaløy at 370 m, and a multi-

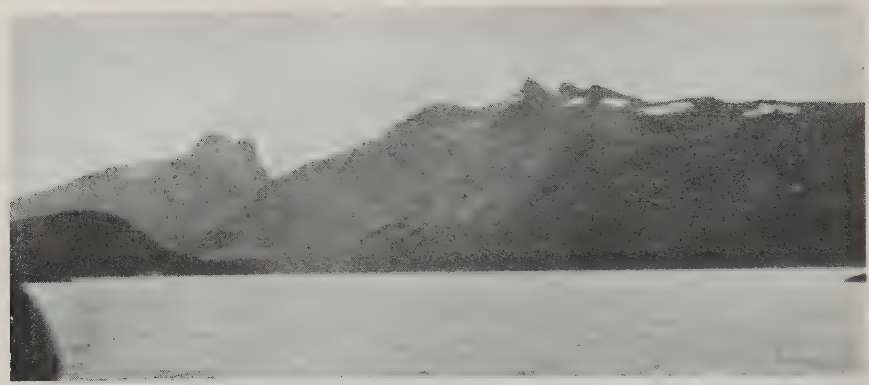

Fig. 8. The Børvasstinds, overflowed by the great ice sheet, but nunataks during the last glaciation. Gr. phot.

tude of the same rock has been found on the west slope of the Kirkesdal at about 450 m, and in the Målselvdal 6—7 km farther to the east at 575 m. Besides blocks of the swedish granite many other rocks have been found as erratics to high levels, on the plateau to the north of the Tromsdalstind to 650 m, on Kvaløy to 600 m, but as their homestead cannot be pointed out, they are of less interest. Of this kind are some huge blocks of a grey granite found on the west coast of Andøy 15—20 m above sea level, but at so low a level also blocks of swedish granite and blocks of gabbro are common.

I have on former occasions treated the eroding work of the great ice cheet, the levellings of plateaus, the roundings of tops and ridges, and the excavations of rock basins in the fjords more detailed (6 and 7) and shall not repeat it here, but generally speaking it can be said that the ice sheet of the great glaciation so thorougly has made its work that all loose material and weathered rock from former days had been taken away. The ice sheet and glaciers of the last ice age, therefore, only found bare, smooth, and fresh rock surface where little was to be done and little has been done. The remaining work would only be to form bottoms and side slopes in the valleys and other details at lower levels.

II. The Last Ice Age.

1. STAGES OF THE ICE BORDER FROM THE MELTING PERIOD

I have formerly called attention to the fact that there along sounds, fjords, and valleys in Northern Norway is a more or less distinct line of partition between a lower concave and an upper convex part of the side slopes (6). At this line between different curving parts moraine terraces and dry river beds either in loose material or in solid rock are often to be found. Erratic blocks and polished rock surface are also common in that level. Such marks show that the edge of a glacier must have been stationary there for some time, and that some melting of the ice on the surface has taken place before recession of the ice from this line.

Such terraces and river beds are often to be found at more levels in the same locality, but the uppermost and oldest ones rise commonly from the coast eastwards in such a way that it must be supposed that they have been formed at the same time, and mark a distinct stage of an inland ice during its melting period. Marks of that kind do not give any information of the maximal stand of the ice sheet, but they can give a hint of the dimensions to be taken into consideration. On the following pages I will give an account of some observations along such border lines.

On Sørøy in southwestern Finnmark about 1 km east of Sørvær is a defile stretching north-south at about 190 m a. s. l. Ice that once must have filled the defile to above 210 m has retired southwards and downwards and during its recession three moraine ridges have been deposited, quite small, but easily pointed out. Between the uppermost ridge and the mountain side is a lakelet. It is likely that the moraines there have been deposited at the border of an ice sheet in melting and not by a local glacier. On the mountain slope east of Hasvåg on the same island is an ice border line 240 m a. s. l. At the mouth of a little valley there must have been an ice dammed lakelet, now a bog. About 300 m to the south of this valley is a lake between the mountain side and a moraine ridge. No local glacier has, however, deposited this moraine, but an ice mass retiring from the land slope. Farther south from Hasvik westwards is a lowland, a former sound, across the island. The mountain party south of this lowland, the southernmost part of Sørøy, rising to 172 m, has been overflowed by an inland ice

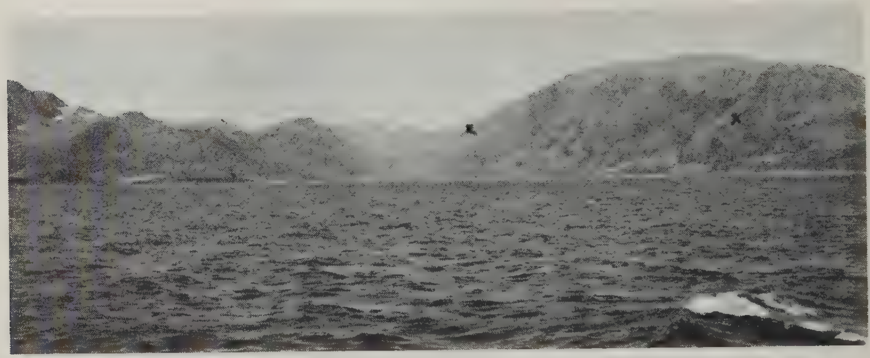

Fig. 9. Sørøy in Finnmark with the Øy-fjord, seen from the Sørøy-sund, rounded by the great ice sheet, but below a cliff a younger ice border line can be seen. Gr. phot.

of little thickness and velocity, for on this part of the island there is a multitude of blocks and boulders of foreign rocks.

On the eastern side of Sørøy the Øyfjord stretches westwards from the Sørøysund. On the northern side of this fjord a horisontal line is seen on the mountain wall about 250 m a. s. l. Above this line is a cliff supposed to have been undermined by an ice sheet with its surface at the 250 m line (fig. 9). On the southern side of the Stjernsund about 5 km east of Øksfjord is a moraine terrace about 320 m a. s. l. and on the opposite side of this sound the steep mountain walls may have been undermined by an ice stream in the sound with its surface at the said level. Along the Kvænangenfjord marks of a similar stage of an ice sheet are to be seen in many places. From Badderen at the head of the fjord leads a road to some copper mines, now abolished. At about 110 m is a terrace of sand and gravel which likely has been deposited between the mountain side and an ice tongue retiring out the fjord. At 260 m a. s. l. is a wide moraine terrace on the eastern side of a valley, and on the opposite side of this valley is a moraine ridge between the river bed and the western mountain slope, and beyond this ridge a lake has washed out shore lines at more levels. The river bed is a canyon, for a part cut in hard packed moraine.

At about 300 m a. s. l. there seemed to have been an ice dammed lake stretching northwards in the valley which at that level is relatively flat. The lake stage was naturally an advanced melting stage. Along

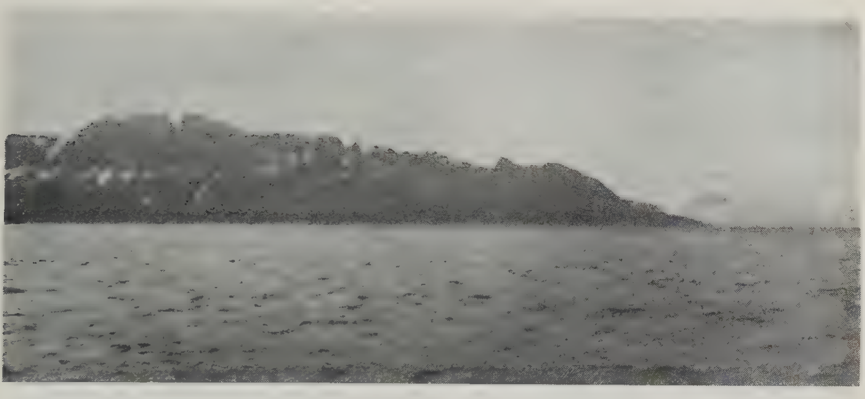

Fig. 10. Ice border line on the north flank of the Kvænangstinds, marked by snow patches in the middle of the mountain wall. Seen from the north. Gr. phot.

the north side of the fjord between Alteid and the Jøkelfjord there are some rock pillars at about the same level, they must have been formed by river action at the border of a glacier. A line is seen at about the middle height of the north flank of the Kvænangtinds, but not measured (fig. 10). Similar lines have been seen along the Nord-Reisa fjord seemingly at a corresponding level.

At Olderelv farm on the eastern side of the Lyngenfjord two lateral moraine levels have been measured 300 and 400 m a. s. l. From the head of this fjord the Signaldal stretches in southeasterly direction to the frontier where a cairn marks the point of contact between Norway, Sweden and Finnland. In this valley about 25 km from the sea a melt water river has once cut a canyon in the eastern mountain slope in the solid rock. The bottom of the canyon is situated about 550 m above sea level. The upper wall of the cut is about 50 m high, the opposite wall about 15—20 m, and the canyon is about 30 m wide and 1 to 2 km long. The river once cutting there must have started its work above 600 m above the present sea level, and the great mass of rock taken away is for a part to be found at the northern end of the canyon where the river had found a passage down to the bottom of the valley. Fig. 11 shows the southern part of the canyon seen from northwest. The mountain seen in the background is Paras. About 100 m below in the same mountain side is another cut, marking a younger stationary stage of the ice border, but this cut is neither long nor deep.

At Breivik farm at the northern end of Breivikeid is a moraine terrace about 280 m a. s. l., but beyond that the mountain sides along the Ulsfjord and the Sørfjord are so steep and naked that no border lines are to be seen.

Near the northern point of Renøy is a moraine terrace 175 m a. s. l., and at Rottenby farm near the south end of the same island is a similar terrace 192 m a. s. l. At Kraknes farm on Kvaløy near the southern mouth of the Kvalsund is a moraine terrace 198 m a. s. l. This border line is rising southwards on the same island to 220 m. On the east side of the Tromsøysund is a nearly continuous lateral moraine level, about 210 m a. s. l. at Movik farm 10 km north of Tromsøy and about 250 m a. s. l. near the mouth of the Ramfjord. Along the Balsfjord this level is not easily pointed out, but in the valley between the heads of the Balsfjord and the Lyngenfjord it is found 430 m a. s. l., at lake Sagelvvatn at 400 m, in the Målselvdal near the Øvrebygd at 575 m, at the mouth of the Sanddal, a side valley to the Dividal, at 680 m, and at the mouth of the Annavassdal at 700 m a. s. l.

At Ganslåt near the mouth of the Malangenfjord a lateral moraine has been measured 193 m a. s. l., but all other lateral moraines along this fjord are to be found at lower levels, thus at Andsnes at 145 and 150 m a. s. l.

At Vikstrand on the southeastern side of Senja is a moraine terrace 260 m a. s. l., at the head of the Sørreisa fjord a similar terrace 300 m a. s. l., and at Løvdal farm east of the sound between Andørja and the mainland a terrace 260 m a. s. l. On the plateau between the Gratangenfjord and the Herjangenfjord are terraces between 190 m and 270 m which must have been deposited in an ice dammed lake between glaciers in the said fjords.

Between Harstad town and the Kvæfjord goes a direct road to Borkenes along a wide valley. The bottom of this valley is covered by a thick ground moraine to above 200 m a. s. l. Lateral moraines are to be found on either side to above 240 m. There are similar moraines on the west coast of the Gullesfjord at Flesnes at about 210 m, at Gunnesdal to about 230 m, on either side of the Sortlandsund at about 220 m, on the Hadseløy to above 160 m. These lateral moraines show that there once has been a large glacier in the Vågsfjord and the Andsfjord sending strong offshoots through more defiles westwards from the Gullesfjord to the Sortlandsund where

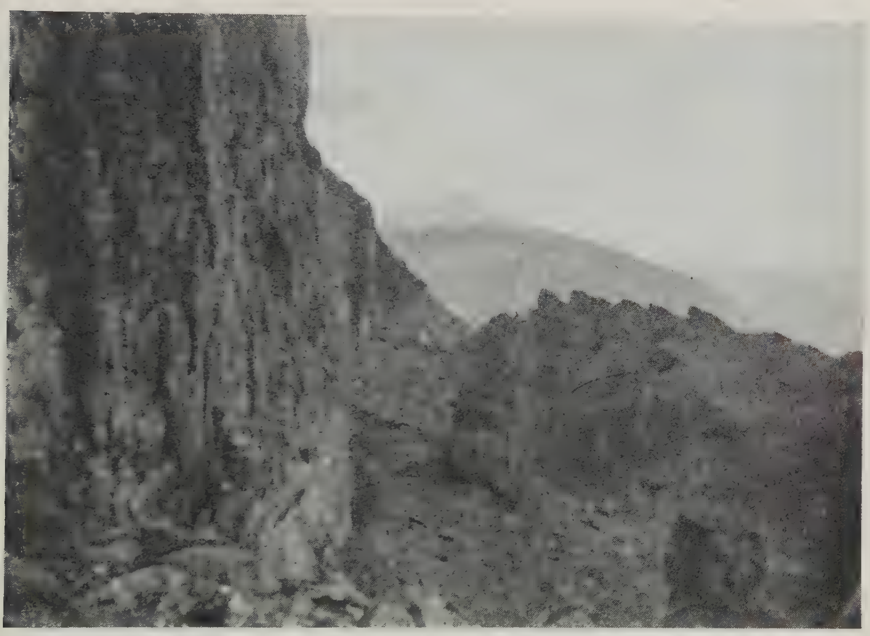

Fig. 11. Canyon cut by a melt water river in the east slope of the Signaldal 25 km from the head of the Lyngen fjord 550 m a. s. l. Gr. phot.

they merged into an ice stream that moved on through the Hadselfjord to the open sea off the western coast of Langøy and Vestvågøy.

The Andsfjord glacier sent two broad ice tongues across Andøy, a southern tongue over the marshy lowland at Bjørnskin, and a northern wider tongue westwards over the Dverberg lowland. This northern tongue has marked its way by lateral moraines and terraces on its southern flank at 240 m a. s. l., and on its northern flank it has undermined outstanding points to perpendicular cliffs that now cut a formerly ice worn surface. The face of Arnipen is such a cliff.

The western part of Vestvågøy is a large glacier trough where ice both from the north and the south has merged together. A thick ground moraine covers the bottom of the trough and rises finely both to the west and to the east. About 10 km to the east of Eggum is a lateral terrace 125 m a. s. l. To the east of this trough blocks and boulders have been found to about 300 m between Valberg and Borge and to the east of Valberg to 340 m. These finds show that the ice sheet must have been quite thin and the movement inconsiderable.

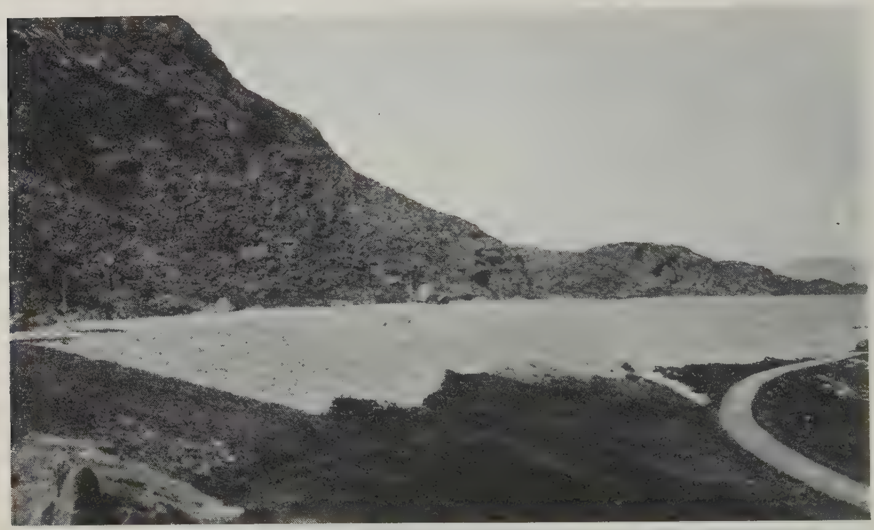

Fig. 12. A strand wall of cobbles on the north-eastern side of Værøy near the north point. Gr. phot.

The outer border of this ice sheet seems to have stopped against the eastern side of Flakstadøy so that this island was scarcely surrounded by the ice during this stage.

It must be supposed that this last inland ice rose to above 100 m on the east side of Værøy. If so this island must have been surrounded by the ice perhaps with the exception of the middle part of its west coast. On the east coast near the north point of the island is a terrace of cobbles of foreign rocks. The foreign material no doubt has been carried by the ice, but at a later date the terrace has been formed by the sea (fig. 12).

The last ice sheet cannot have reached so far out as Røst. I have surveyed the Røstland rather closely but could not find foreign rocks or other marks of a late glaciation.

Between the Ofotenfjord and the Salta—Skjerstadfjord lateral terraces are rare. In the Håkvikdal south of the Beisfjord near Narvik are, however, some terraces between 200 and 270 m no doubt deposited in an ice dammed lake, but this lake must have existed at a relatively late date. Farther south not a few peaky mountain tops are to be found within that district which must have been nunataks for a long time, most likely during a greater part of the last ice age. They

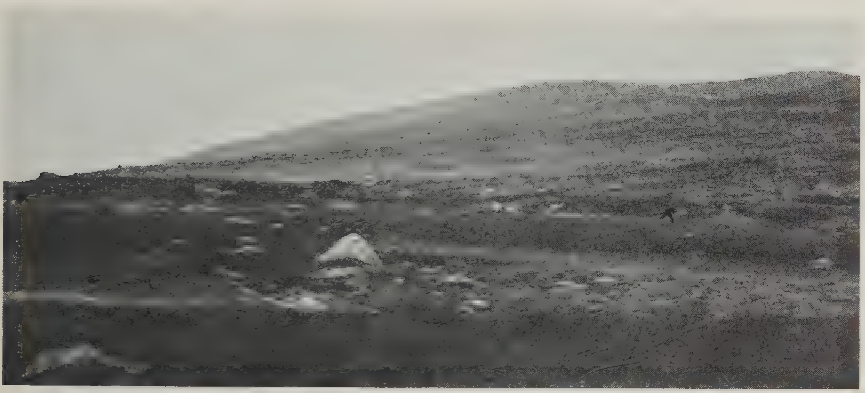

Fig. 13. A dry river bed in level with a defile between Saltdal and Bjellådal about 844 m a. s. l. Gr. phot.

are often like a hat with a lower party, a rim which must have been covered by the last ice sheet, and a crown more or less as nunatak, rising above the ice.

From the Saltdal at Bergulnes farm runs a line of telegraph through the Bjellådal southwards to the Rana district. It passes the watershed between the Saltdal and the Bjellådal at a level of above 800 m. The topographic map has 844 m and by two aneroid measurements 820 m have been found. Just at the level of the divide is a river bed showing that a river must have passed from Saltdal to Bjellådal at that point (fig. 13). In the northern part of the Bjellådal was at that time an ice dammed lake. This lake was dammed by an ice tongue from the south, an offshoot from a large glacier in the Dunderlandsdal as pointed out by Rekstad (18). At the northeastern end of the present lake great terraces of sand and gravel are to be found which must have been deposited by the said river, for at the present time only small brooks are to be found there, running on hard ground and surrounded by bare rocks so it would not be easily understood whence they should have taken such masses of loose material as there deposited if it be deposited by them.

The ice dammed lake had during its highest stand an outlet through a defile northwards to a valley called the Harrodal. Fig. 14 shows a shore line from that time 765 m a. s. l. The bottom of the dry river bed at 764 m is flat and its width is 100—150 m. The river

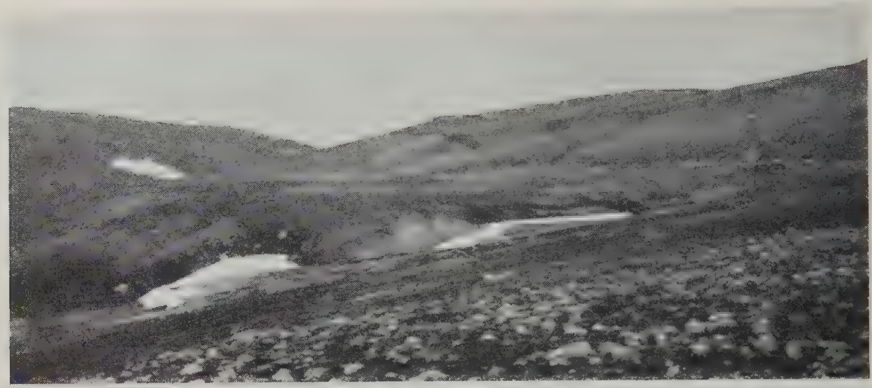

Fig. 14. A shore line showing the level of the older ice dammed lake in the Bjellådal 765 m a. s. l. The outlet of the lake went northwards from the patch of snow seen to the left on the photo. Gr. phot.

started at the point where a patch of snow is seen to the left on the photo.

The bottom of the Harrodal lies about 600 m above sea level, and in the valley was a lake dammed by the glacier in the Saltdal. In this lake the loose material carried by the said river from the Bjellådal and other glacial rivers was deposited. Fig. 15 shows 5 terrace steps washed out in these deposits. While the lake existed the level of the ice surface in the Saltdal must have been situated at about 650 m. Such a level of the ice border has farther south been marked by a shore line of a border lake not far below the Hesjehomp telegraph hut.

While the melt water river was running across the watershed to the Bjellådal, the surface of the glacier in the Saltdal must have been much higher, at least 900 m above the present sea level. The Dunderlandsdal glacier which dammed the lake in the Bjellådal must have been of similar dimensions and no doubt was connected with the Saltdal glacier through a glacier in the Lønsdal at about 1000 m above the present sea level and parallel to the frontier. Despite the great elevation of the surface of the ice at that time the supply of ice from Sweden across the frontier must for all that have ceased or was about to be so, and the time of the ice dammed lakes must therefore represent a rather advanced stage of the melting of the last inland ice. After that time the glaciers in our valleys may have been dependent only of local supply of ice, and it is likely that they soon were reduced to dead ice masses as the local supply scarcely was great enough to

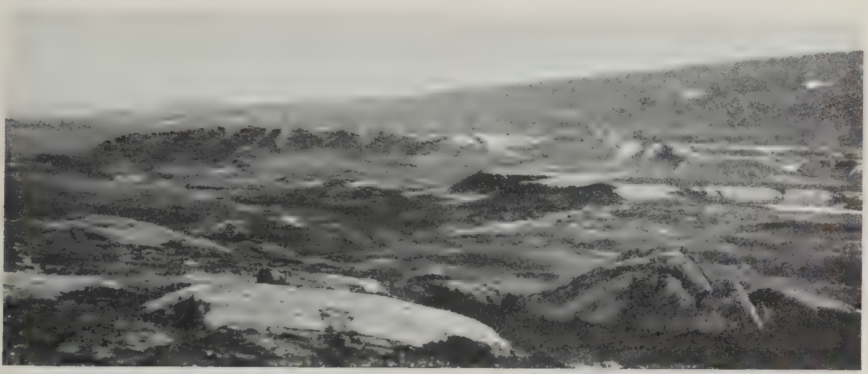

Fig. 15. Terraces deposited in an ice dammed lake in the Harrodal about 600 m a. s. l. Gr. phot.

keep them moving. This, however, only holds good in Nordland. In Troms, on the contrary, the valley glaciers still were fed from the east, and perhaps in the Tysfjord district as well.

The Røvassdal is a side valley to the Dunderlandsdal, stretching northwards into the Svartis area. On the western side of this valley is a lake, Rengårdsvatn, 364 m above sea level, and to the south of this lake the entrances of three grottos lie on a line near 400 m a. s. l. The lake must once have been dammed by the ice to above 400 m, and during this time water must have forced its way down along crevices in the rock, a limestone, and there formed the grottos now found there. To one of the grottos, the Larshol, the entrance is narrow and difficult to pass, but once through, the passage opens into a veritable valley, falling with the dip of the mountain side. There is a roof of mica schist and on the bottom is running a brooklet which disappears in some narrow crevices about 70 m a. s. l. In the narrow passages near the entrance no running water is now to be seen. Of the same age or perhaps somewhat younger is a cavern in the opposite side of the Røvassdal, the Grønli grotto. This grotto has three entrances, the uppermost one at 236 m a. s. l.. The outer part of some of the passages leading inwards to the subterranean galleries has been filled up with ground moraine pressed in by the ice. In this material blocks and boulders of granite have been found. These blocks must have been carried at least 10 km from their homestead. The brook running through this grotto has a subterranean course for several km and falls from a level of about 260 m to 50 m a. s. l.

Still younger are some caverns on the northern side of lake Langvatn in the Rana district. The Hammernes grottos have their entrances at a level about 200 m. Further details of these grottos are to be found in a paper by Dr. Gunnar Horn: Über einige Karsthöhlen in Norwegen. — Mitteilungen über Höhlen- und Karstforschung. Jahrgang 1937.

On the preceding pages some scattered observations have passed in review, moraine terraces, dry river beds cut by melt water rivers along the edge of valley glaciers, shore lines washed out in ice dammed lakes etc. Such marks have been found at several levels and must therefore be of different age. Those which have been found on outlying islands must be the oldest and are supposed to date from an early part of the melting period, but not even those are likely to mark the maximal stage of the surface of the last inland ice. With ice surface is here meant the surface of the ice flow from the east, not the surface of glaciers in locally glaciated areas above the level of the inland ice. Such locally glaciated areas were the Svartis peninsula and a greater part of the Lofoten and Vesterålen islands which no doubt did rise above the level of the last inland ice.

2. THE MAXIMAL THICKNESS OF THE LAST INLAND ICE

To fix the thickness of the last inland ice at its maximal stage will be, after all, no easy task as it would call for detailed investigations within the loftiest mountain parties. The present writer has had neither time nor strength to take on such investigations, but in travelling inland I have always tried to collect material concerning this question, and if I was not able to form an opinion based on direct observations in the field I have been going over the topographic maps in order to find a hold. Rolling mountain plateaus with ground moraine cover in depressions and naked knolls scantily weathered may have been overflowed by the last inland ice as well as ridges with ice-worn forms, especially if they have been flattened on top and are stretching southwest—northeast. Summits rising steeply from a flatter base must be supposed to have been nunataks, at any rate for a long time, during this glaciation. Cirques are to be found on outlying islands at or near the present level of the sea, but on the mainland they rise to higher levels, increasing with the distance from the coast. It is true that some cirques are of a younger date, engraved after the recession of the inland ice from the outer coast line, and some cirque glaciers are yet working, but it can, however, scarcely be doubted that also at the maximal stage of the ice sheet local glaciers eroded in cirques and trough valleys on the lee shore of land parties too high to be overrun by the inland ice or situated above the level of the flowing ice sheet.

By comparing scattered observations and statements derived from the maps I have come to results seemingly fair. Between Børgefjell and Sulitjelma the last ice flow seems to have passed the frontier with its surface about 1500 m above the present sea level. Between Sulitjelma and Ofoten the elevation was 1300—1400 m, and in Troms fylke 1200—1300 m. The surface of the ice sheet had a faint westerly or northwesterly dip. West of lake Røsvatn the land surface seems to be ice worn to about 1300 m, and the Reinfjell ridge running south—north and rising to 800—900 m has been flattened on top by an ice flow from the east. Cirques are not to be found in this district except between the Lukttinds and the Dårtinds. The highest summit of the Lukttind group is 1344 m high and is supposed to be a nunatak from about 1200 m upwards. The land west of the inner part of the Vefsenfjord with summits above 800 m was completely covered by the ice, and on the Alsta island the ice surface must have been situated between 800 and 900 m. The well known summits "the Sju Søstre" were then nunataks. Dønmannen near the southern end of Dønna island may have been nunatak from about 500 m. At similar levels lay the surface of the ice west of the Svartis area. Lovunden island is supposed to have been nunatak above 400 m, the steep uppermost part of Hestmona island nunatak from 450 m. On the coast of the mainland this level rises to about 800 m. This is in quite good accordance with statements by Granlund from 1935: On Dønna and Tomma islands weathered rock down to 500 m, in Sjona glacial sculpture to about 700 m, nunataks above 800 m (2).

In the Beiarn district all the rock ground seems to have been overflowed by the last inland ice. Two summits, Tellingen 1248 m and Ramgjeiltind 1237 m, must on account of their peaky form have been nunataks from 1100—1150 m upwards. The ice flow was not thick enough to cross the mountain party west of the Beiardal, and it therefore parted in two different ice streams, the one going northwards to the Saltafjord and the other making its way through the Dunderlandsdal and the Ranafjord to the outer coast.

On the southern side of the Salta-Skjerstadfjord the highest summits of the Børvasstinds and the Beiartinds must have been nunataks above 1000 m. North of this fjord the Steigtind has likely been nunatak from about 650 m, some peaky summits near the mouth of the Follafjord from 700 m, Landego island from 500 m upwards.

On the map of Narvik mountain parties with cirques and nunataks are to be found above 1000 m, on the map Ofoten to above 900 m and on Tjelløy between the Tjellsound and the Ramsound to 850 m.

Along the southeastern coasts of Lofoten islands the surface of the ice flow seems to have sunk to 450 m at Svolvær and to between 400 and 300 m on Vestvågøy. On Værøy it is supposed to have been situated between 100 and 150 m above the present sea level.

As for Troms fylke only maps of the south and southeastern part are fit for the said use, and therefore not much can be made out of them. The level of the ice surface must have sunk there as farther south to the west and northwest. On Rolla and Andørja the surface must have been situated between 700 and 600 m, on Hindøy between 600 and 500 m, on Grøtøy at about 500 m, on the southern part of Senja at about 400 m above the present sea level. Farther north the surface lay still lower, between the islands in the northern part of Troms fylke at about 300 m, around the southern part of Sørøy about 300 m. It is known that in the eastern part of Troms fylke between the heads of the Lyngenfjord and the Balsfjord and the great lake Altevatn, is a series of lofty summits between 1200 and 1500 m above sea level. The botanist Reidar Jørgensen, who has ascended most of these summits, has embodied his impressions of these mountains in a skeleton form, a "Normalgipfel". From the bottom of a valley about 200 m above sea level the mountain side rises to about 1100 m where it passes into a "Blockmeer" less steep and covered with a multitude of blocks (13). I think it likely that the surface of the inland ice at its maximal stage is to be found in the Blockmeer 1150—1250 above the present level of the sea.

In conformity with what has been stated above the last inland ice must have had its greatest thickness in Helgeland, and there it must have advanced far out on the continental shelf. North of the Svartis area the ice flow also passed the present coast line with a considerable thickness and no doubt covered a large part of the bottom of the shallow sea off shore. Between the Ranafjord and the Saltafjord there is so long a distance that scarcely the said ice streams did merge

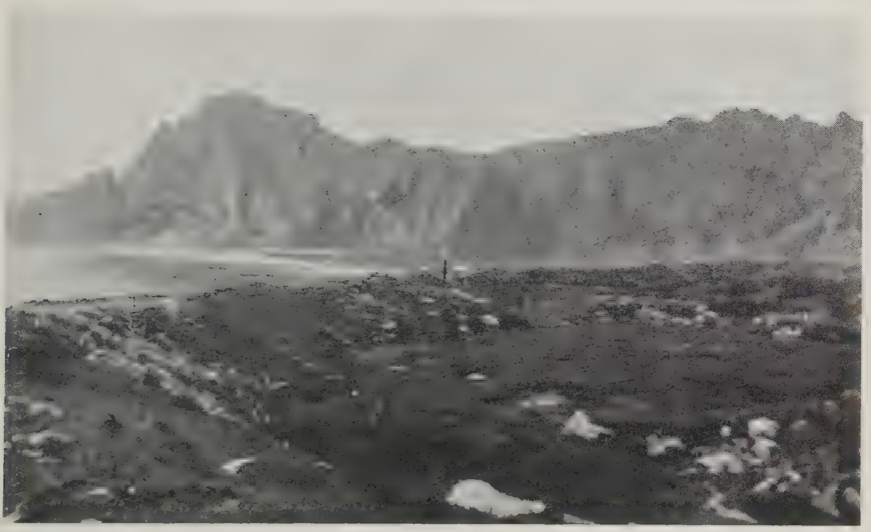

Fig. 16. A moraine deposited by a local glacier at Bleik on Andøy. North of the moraine shore lines are to be found to 26 (48?) m a. s. l. Gr. phot.

into one, at all events near the coast of the mainland, but there local glaciers from the Svartis area were great enough to fill the interspace between them, and therefore it must be supposed that there still was a continuous ice front facing the sea from the southern Helgeland to the Lofoten islands. At the same time a strong local glaciation of these islands must have contributed to increase the ice streams on both sides of these islands.

North of Hindøy a large Vågsfjord glacier was flowing westwards. Farthest to the south great ice masses were pressed through pass valleys westwards to the Sortlandsund. A part of the front was running up against the southern mountain party of Andøy and was turned off to the south. Farther north two wide ice tongues crossed the lowlands of Andøy without overflowing the middle and northern mountain party. On the western side of these mountains local glaciers worked at the same time more or less in contact with the inland ice. On the eastern side of the mountains the inland ice did not everywhere get contact with the mountain side because local glaciers had come into being there before the arrival of the front of the inland ice. Along the east side of the northern mountain party is a moraine ridge at some distance from the mountain side and this ridge seems to have been built by the inland ice and local glaciers in common. This ridge tells so much in the field that it is seen on the topographic map. Fig. 16 shows a moraine deposited by a local glacier at Bleik west of the northern mountain party. This moraine cannot, however, have been built while the inland ice had its maximal stage, for then the coast off Bleik must have been blocked up by the inland ice, and the local glacier may have been greater and advancing into the sea merging together with the inland ice.

The high western part of Senja was not overflowed by the inland ice during the stage here dealt with, but a narrow glacier tongue, however, crossed the island through a valley from the Gisund at about the middle of the island. Both north and south of this passage the west coast lay on the lee side of high mountain parties, and all the fjords there were filled with mighty glaciers fed locally. To what extent these glaciers were in contact with the inland ice before the melting period set in is not easily conjectured, but like the glaciers on the west coast of the Svartis area they may have filled up a space between the northern flank of the Andsfjord glacier to the south and of a great Malangenglacier to the north. After the melting of the ice barrier west of Senja these fjord glaciers have been true local glaciers for a long time.

On the west coast of Kvaløy north of the Malangen glacier similar fjord glaciers have existed and have forced their way far into the island, but only one has cut across to the east coast. This cut is the Kalfjord. Through this passage the last Balsfjord glacier sent a branch westwards to the sea, but else only local glaciers have been at work cutting deeply into an old plateau land formerly levelled by the great ice sheet, and there is, therefore, a distinct difference between the old plateau to the east with its erratic blocks of foreign rocks and the fresh surface of the steep walls surrounding the cirques and trough valleys in the western part.

The southeastern part of Ringvassøy along the Grøtsund is a highland with rounded summits, and plateaus of a noteworthy extent are not to be found, but on the lee side of these mountains large local glaciers have been at work, the largest being the Skogsfjordvatn glacier. These glaciers cannot have been in any intimate contact with the inland ice flow in Kvalsund and Langsund. Along the border of the said local glaciers great melt water rivers must have been in action, for on the east side of the Skogsfjordvatn glacier there are two dry river beds, the one a 5 m deep canyon starting at 170 m and ending at 130 m, the other nearly parallel to the former starting at 153 m and ending at 120 m above the present sea level. At lower levels similar beds are also to be found, but they are neither so deep nor so continuous.

The surface of the last glacier in the Tromsøysund must have been situated between 350 and 400 m above the present sea level at its maximal stage, for some horisontal lines in ground moraine are to be seen at that level on the east side of the sound about 10 km north of Tromsøy. Offshoots from this glacier were the glaciers which made their way through Kvalsund and Langsund and merged together between the islands north of Ringvassøy, forming an ice plateau about 300 m a. s. l.

Glaciers of similar dimensions as the Malangen and Balsfjord glaciers also filled Ulsfjord, Lyngenfjord, Nordreisafjord and Kvænangenfjord and all sounds between the islands in the western part of Finnmark, and off the mouths of the fjords and sounds these glaciers merged into one, forming an ice barrier with a continuous front against the sea between Vannøy in Troms and the southern part of Sørøy in Finnmark. A part of the west coast of the last named island must have been blocked up by the ice to some extent, but possibly not the northern part of its west coast.

3. EVIDENCES OF FOSSILS AND LIVING PLANTS OF A LAST ICE AGE

On the previous pages I have tried to give an account of the probable dimensions of an ice sheet presumed to be the maximal stage of a last ice age. It may then be a question whether the said stage be only a melting stage of the great ice age or actually an independent ice age separated from the former by an interglacial period. The ice sheet of the great ice age was no doubt so thick and moved so quickly that scarcely no space was left for local glaciers even if some nunataks may have risen above the surface of the ice. During the melting of this great ice sheet some remnants of ice may have been left on the west side of islands, but if so they were for a greater part "dead" glaciers with slight eroding power and cannot, therefore, have done the eroding work the traces of which are so conspicuous there. It is therefore more likely that these glaciers were of local origin starting their work at the beginning of the last glaciation, going on during the advance and maximal stage of the last inland ice and the following melting period if the climatic conditions were favourable for their existence and supply.

Of interest in this connection is further an occurrence of loose material with fossils found in the town of Tromsø, in a quarry on the St. Hans Haug. In the lower part of the quarry 42 m a. s. l. was a slate rock of relatively thick foliation and there sand and gravel had been pressed into the rock between the plates to a thickness of about 6 cm, and in this material were shell fragments of which the two mollusk species *Mya truncata,* Lin. and *Littorina rudis,* Maton could be determined. Besides the shells there was found a stone with an impression of a leaf of*Alnus incana* of the same type as now is living on the Tromsøy. *Alnus* could not have lived on Tromsøy while a glacier filled the Balsfjord or was near there, and *Littorina rudis* is a boreal gastropod. The occurrence must therefore be interglacial. About 150 m north of the quarry and 10 m higher shells have been found pressed into moraine material 6 m below the surface. A similar occurrence was found by Kiær near the top of the island 3 m below the surface. Among the species found was also *Cyprina islandica,* Lin., a typically boreal species (7).

It may be objected that this fossiliferous material is not strong and the reasoning less convincing but then the botanists step in helpfully. Nordhagen mentions a good many plants which he calls interglacial hibernates. These plants are only to be found either within a limited area in Northern Norway or in the loftiest mountain parties in Southern Norway or within both these areas but not elsewhere in Scandinavia or adjoining parts of Europe. Nordhagen is of opinion that these plants have immigrated to our country during an interglacial period and here survived later ice ages in ice free and protected places (14 and 15). As during our great ice age, the last total ice sheet, in my judgement, was so thick that practically the whole land was overflowed by the ice, it is not thinkable that vegetable life could survive in Northern Norway and find resorts which were not eroded by the ice. The occurrence of these plants, therefore, appears to me to be an important and strong proof of an interglacial period between our great glaciation and a last glaciation, the last ice age. The last interglacial period was long enough for the immigration of a new flora, and during the last ice age there were plenty of resorts for a hardy mountain flora to be found.

III. The Late Glacial Shore Lines.

1. SOME GENERAL REMARKS

The shore lines in Northern Norway have for a long time been known and supposed to be marks of past sea levels, and after the time of Bravais about 100 years ago many interested men have measured them and dealt with them. Among others must chiefly be named Karl Pettersen, Andreas Hansen, Helland, and Tanner. After getting an appointment in Northern Norway also the present author began to take an interest in the shore lines and in the course of time I have collected a material of levellings within an area stretching from Bindalsfjord in the southern Helgeland to Hammerfest in Finnmark.

I have never had much time left for working out this material, and therefore I have not been able to give a summary of it till now. Nor was the former way of working by drawing of isobases much practical in use when the material increased as more levels were pointed out. When Helland measured shore lines in Troms fylke only two levels were taken into consideration, broadly speaking the lines b and f by Tanner, but by including fainter lines it soon appeared that in the northern part of Troms fylke were at least 5 lines and in the southern part 6 lines, and still more complicated was the situation in Nordland where only a few measurements left no doubt that above 12 different levels were there to be found. To follow all these levels in the field so closely that each single line could be known apart was practically impossible. Drawing of isobases must very commenly be postponed in anticipation of new and better material, and in that way the working could be retarded for years.

Tanner, in his book from 1930 where he deals with the quaternary geology of the northernmost part of Finnland, rejects in many points the old views, and his line of arguments comes so often across habitual theories and conceptions that one must go in for reconsideration and test, and so far has his criticism been useful, but more important than the criticism were his positive contributions in pointing out a new way of graphic figuration of the shore lines, the epeirogenetic spectrum. It is clear that if this method can keep what it promises it would be a find and an excellently valuable means in the study of the shore lines. I have tested the method on my material and have come to the result that it is indispensable. If the levels cannot be identified by the aid of the spectrum they can even less be identified by the field work, for the shore lines lie often so close to each other or they are so faint that they cannot be followed continuously for a longer distance.

I have up to now only dealt with material collected by myself for it was always at hand, and the localities were known from the field work so their relative value could be compared.

Tanner has used in constructing his epeirogenetic spectra the Tapes line — or more definitely the b-line — as the leading line when inserting the localities in a spectrum. This implies, however, that the b-line has been safely fixed during the field work. It may have been done with sufficient exactitude on the coast of Finnmark and Northern Finnland, but even in the southern part of Troms fylke some insecurity is met with, and more difficult it is in Nordland fylke where the b-line is not in general better developed than any other line. In order to get a more safe notion than scattered and casual values could give, I have, therefore, in applying all the levellings at hand made out the line from place to place southwards, and the result of this work are the isobases of the b-line, pl. 1. As will be seen the isobases run, broadly spoken, parallel and equidistant. Only in the northern part of Troms fylke and the adjoining part of Finnmark a diverging course is initiating, and the distance between the 5 m isobase and the 10 m isobase is greater than the mutual distance between the other isobases. Whether this is correct or not cannot be safely said, for in the peripheric part of the once glaciated area the shore lines lie so near together that a younger line may have been mistaken for the b-line during the measurements.

2. THE SHORE LINE DIAGRAM

Plate II is a diagram drawn after the method of Tanner to a scale about that of his from 1930 both vertically and horizontally, vertically 1 m to 1 mm, horizontally 200 m to 1 mm. For the diagram only 312 measurements have been chosen out of the material from Northern Norway, in the first instance because the whole material is not yet worked out with suffient accuracy, and also because a diagram in the said scale would be inconveniently crowded if too much material was inserted. Besides the levellings from Northern Norway, however, 8 levellings from Novaya Zemlya have been included because they were easily fayed in though they belong to another area of depression. This adaptation must depend on a law-directed parallelism between

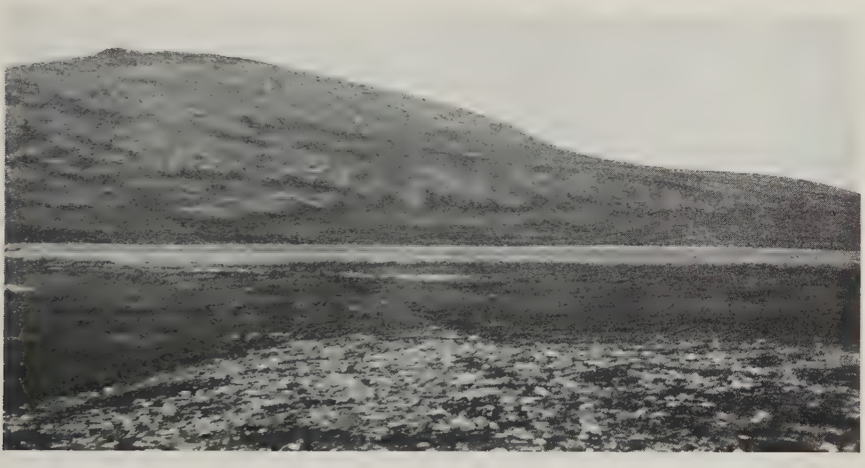

Fig. 17. A strand wall of cobbles with a shore line washed out on the distal side of the wall at Hasvåg on Sørøy 51,8 m a. s. l. Gr. phot.

the movements in different depressions at the same time which would have been difficult to make out without the aid of the diagram, and it is a proof of the usefulness of the method. It is not easily done to insert the levellings in their proper place in such a diagram, and I do not dare to believe that this end always has been attained, but the departure cannot be great.

The uppermost lines p to n′ whether found in Northern Norway or in Novaya Zemlya are very doubtful marine shore lines. The measurements concerning them have mostly been carried out in places on the open coast where the rock surface was intensely weathered or have been taken on sounds and fjords where lines may have been washed out by running water at the ice border. All the figures from Novaya Zemlya above 272 m have besides only been found by aneroid.

The uppermost shore line which certainly is marine is n, pointed out in not a few localities. At Hasvåg on the west coast of Sørøy in Finnmark this line is very sharply engraved in an open situation to the sea 51,8 m above sea level, and on Trenyken, one of the islands of the Røst group, it is found at the entrance to a cave 39,9 m a. s. l. As this line is marking the upper marine boundary in such outlying places, it is supposed to be the oldest marine shore line after the maximal stage of the last glaciation (fig. 17).

The lines from m to d_4 are rather accurately fixed in number and position in the diagram, for a greater part of the levellings are from the later years and carried out with great care. Farther down where the shore lines are more densely crowded the measuring errors have a greater play, and there corrections of some importance must be expected when more levellings are taken into consideration and diagrams to a greater scale are used. This applies especially to the c-lines and the a-lines.

For evading new difficulties regarding the designation I have always used the same letters as Tanner on lines identical with his. If in my diagram lines were found which were not to be identified with any lines in Tanner's diagrams, or if some lines were doubtful, I have only noted such lines with a point.

The levellings used for the drawing of pl. II are to be found on the following pages. The figures have been taken directly out of the journals written during the field work. In these journals remarks have generally been passed on every single locality and each shore line which was pointed out. These remarks have been left out in the list of the localities in order to save place. But as the relatively best localities have been chosen for the diagram, only the remarks on each individual shore line are really missing in the list.

3. LEVELLINGS USED IN THE DIAGRAM

1.	Sørvær on Sørøy	3,8 6,5 11,1 12,6 18,3 28,8 43,2.
2.	Bleik on Andøy	4,4 5,5 13,2 15,4 17,5 20,7 23,4 24,5 26,6 40,4 48,1.
3.	Eggum on Vestvågøy ...	4 5,9 7,8 9,9 11 13,8 16,5 18,6 24,2 26 42.
4.	Høines on Vestvågøy ...	4 8 10,9 18,1 20,1.
5.	Kvalnes on Vestvågøy ...	4 8,3 10,3 17,8 18,5.
6.	Skagen in Bø, Langøy ...	5 6,1 11,3 15,3 22,2 26,2 35,8.
7.	Knutstad on Vestvågøy...	4,4 8,3 20,4.
8.	Bø on Andøy	3,3 6,7 13,7 16 18,3 24,4 28,6.
9.	Vik on Vestvågøy	2 3 4 4,6 5,9 7,9 10,3 14,1 19 24,1 55 68.
10.	Toften on Langøy.........	6,1 11,9 15 19,7 29,6 38,1 62?
11.	Trenyken on Røst	4,6 7,9 9,6 16,5 39,9.
12.	Bergvik on Hadseløy ...	7,6 17,7 18,7 28,9 31,7.
13.	Risøyhamn on Andøy ...	7 15,7 16,2 18,9 28,1 30,1 32,1.
14.	Langnes on Hadseløy ...	6,9 17 20,9 30,2.

15. Valberg on Vestvågøy ...	5,5 12? 17 23.
16. Hadseløy, east	8,4 17,3 33,3.
17. Vedøy on Røst	5,2 8,2 8,7 9,6 11,4 17,1 33,5 36,3 37,6 48,7.
18. Værøy, north	2 4,6 5,6 6,2 7,9 9,6 11,4 15 17,6 31.
19. Hasvåg on Sørøy	3,4 4,8 5 7 7,5 7,8 9,3 11,8 13,8? 14,3 15 16,7 18,5 20,5 21,5 22,5 24,4 26,9 28 29,3 32,1 34 35,6 37,7 39 40,5 41,6 51,8.
20. Helgøy	9,6 15,8 29.
21. Holand on Langøy	5,6 9,4 19,3 40.
22. Skogsfjord on Ringvassøy	3 4 9,7 16,8.
23. Vengsøy west of Kvaløy	9,9 12,1 18? 21,2 23 24,9 39,9.
24. a. Hasvik on Sørøy, west	7 16,2 31,2 33,2 56,9 60,3?.
b. Værøy, south	2,8 6 10,4 14,4 17,7 32 34,3 41,9 61,8 80,5.
25. Hasvik on Sørøy, east ...	4,1 6,3 9,2 13,3 20,2 22 24,6 30.
26. Breivik on Senja	10,2 17,5 20,4?
27. Sandvik on Senja	10,3 19.
28. Mefjordvær on Senja ...	10,4 18,1? 19,1 44,4?.
29. Strand opposite Sortland	6,2 9,1 21,8 35,1? 41,3.
30. Kjerringvik on Senja, west	10,8 21,2.
31. Finnsæter on Senja, west	11-22.
32. Mellemjord on Vannøy...	11 12 23 27,4 34,3.
33. Rekvik on Kvaløy	4 13,6 23,3 26,2 43,4.
34. Tronjord on Kvaløy	5,9 11,5 26,3.
35. Bukkemyr on Senja	11,4 22.
36. Finnvik on Ringvassøy...	5,4 12,3 25.
37. Gryllefjord on Senja ...	11,2? 12,2 23,7.
38. Tromvik on Kvaløy	12,4 19,6 23,6 36,9.
39. Meltefjordnes on Sørøy...	3,6 9 12 31,2 41,2 58 64,3.
40. Finnsæter, Kvæfjord ...	6 12,4 25,7 47,3.
41. Vasstrand on Kvaløy ...	5,5 15,4 27 29,8 51,8.
42. Kårvik on Ringvassøy ...	2,4 3,9 12,4 24,1 25,1.
43. Andersvik on Karlsøy ...	7,3 13,3 28,1 30,1 32,1.
44. Fuglnes at Hammerfest...	3 4 6,5 10 13,7 19,2 26 30 34,6 41 51,4.

45. Gresnes, Kvæfjorden ...	3,3 9,5 15 28,5 48.
46. Simavik on Ringvassøy ..	6,9 14,2 32,5 42.
47. Hersfjord on Langsund...	5 13,5 30 32,5 50,6.
48. Sigerfjord, Sortland	8,5 14,3 22,8 30,2 36,7 38,7.
49. Løkvik on Senja	14,2 29,5.
50. Karlsøy near the church	7,3 14,5? 14,9 32,7.
51. Skatøren on Langsund...	3,5 6,5 14,3 25 29,5 33,6 53,2.
52. Bjarkøy	14,3 32,1 33,1? 39,9 42,1.
53. Futrikelv on Kvaløy	7,8 14,9 34,1.
54. Gamnes on Ringvassøy ..	6,6 14,8 23,5 36,3.
55. Buvik on Kvaløy	14,7 32.
56. Gunnesdal, Kvæfjord ...	5,7 8,6 15 32,5 42,5 55,4 73,7?
57. Kalfjord	6 14 36,3.
58. Elvevoll on Reinøy	3,1 6,8 7,8? 15,8 34.
59. Lanes on Senja	6,4 15,4 33.
60. Ganslåt on Senja	6,6 15,4 34,5 67,9.
61. Kattfjord	1,3 5,9 15,5 32,4.
62. Flesnes, Gullesfjord	3,5 15,8 32,4 35 40,4.
63. Ersfjordbotn on Kvaløy	5,3 17,2 34 52,9.
64. Greipstad on Kvaløy ...	3,3 3,8 5,8 16,3 28,8 35,7 39,3 42.
65. Krabbenes on Kvaløy ...	6,7 15,8 38.
66. Kraknes on Kvaløy	6,1 15,9 38,4.
67. Glimma on Ringvassøy ..	6 15,5 35,4 38,9 48,1.
68. Røsnes on Ringvassøy ...	3,6 6,3 14,6 16,3 23,8 38,9 39,7.
69. Fursæter, Gullesfjord ...	3,5 16,4 33,2 39.
70. Finnkrokan on Reinøy ...	6 15,8 24,8 32,6 39,3.
71. Vang on Senja	8 16,4 37,7.
72. Finnland on Kvaløy	6,9 16, 7 17,8? 40,3.
73. Storelv on Kvaløy	6,5 16,7 17? 23,2? 41,1.
74. Bakkejord on Kvaløy ...	7,1 15,8 19,8 38,3 53,6.
75. Håkøybotn on Kvaløy ...	7 18 43,4.
76. Strømsnes on Senja	7,8 17 40,4.
77. Skittenelvhaug, Grøtsund	7 17,2 39,7? 40,6.
78. Håkøy	17,3 25,2 26,5 42.
79. Mjelde on Kvaløy	6,2 16,7 38,4.
80. Skjervøy	9,3 19,1 31,5 48,2 50,9 55,4.
81. Bay east of Øksfjord ...	4 7,5 17,7 28,7 39,2 63,1 86,7 94,3?.

82. Movik, Tromsøysund	6,2 7,7 17,4 38 41,7.
83. Vågnes, Grøtsund	5 7,5 17,6 38,6 41,5.
84. Rottenby on Reinøy	6,6 15,9 25,6 27 34,1 40,2 70,6 93,4?.
85. Borkenes, Kvæfjord	2 3,3 17,7 42 53,4 90,5?.
86. Snarby, Grøtsund	8,6 17,9 29,1 38 44,3? 45,2.
87. Rødberghamn, Malangen	2,1 3,1 5,2 8,6 16,9 26,3 39,9 48,4 51,8.
88. Sandnes on Tromsøy	4,6 7 17,7 40,1.
89. Innpollen in Rognsund	3 8 18 22 41 45 61 (aneroid).
90. Jøkelfjord	11 22,3 25,3 32 35,2 49,1 55,9 66,3 76,4.
91. Strømsbukt on Kvaløy	7,1 18,1 30 41,7 50,6 68,6.
92. Tenskjær, Malangen	8,2 19,7 33,9 50,9.
93. Eidstrand, Ulsfjord	10,5 18,7 28,7 36,8 50,8 78 99,4 118,4 136.
94. Våg west of Harstad	11,4 18,5 26,2 40,4 45,2 56,5 83,9 86,5?
95. A Bay north of Sandnes on Tromsøy	7,6 18,4 27 36,6 42,5.
96. Nord-Lenangen, Ulsfjord	7,8 18,6 28 32,7 37,8 46,9 67,8 75,4.
97. Stakkevollene on Tromsøy	7,9 17,8 18,5 27,5 37,9 38,5 42,4 44?
98. Workin on Tromsøy	6,9 7,8 18,4 44.
99. Myrlund on Senja	9,6 18,7 35,2 48,6.
100. Tomasjord, Tromsøysund	3 6,6 7,1, 19,4 26,8 29,4 30 39,8 41,2 65,9 72,5 92,9?.
101. Skognes on Senja	10,7 18,5 33,3 42 48,3.
102. Slåtnes on Kvaløy	7,4 19,5 37,3 44.
103. Fritsvoll, Malangen	8 10 19,5 31,3 38,7 44,9 50,1 62,1 71 77,3
104. Sand on Sandøy	7,5 13,9 18,9 35,1 36,3 41 49.
105. Gjøvik, Malangen	3,9 10 19,1 26,6 30,6 37 44 49 51,4.
106. Sverresborg, Hungeren	7,5 19,3 30 41,4 46,2 57,4 68 71,5?.
107. Mølnevik, Vågsfjord	19,5 51,5 54,5 60.
108. Steinbakken on Kågøy	6,5 9,7 12,9 19,6 46,6.
109. Andsnes, Malangen	3,4 19,8 43,5 50,1.
110. Sollien, Tromsøysund	7,5 19,3 29,3 37,5 45 70,3?.
111. Bentsjord, Tromsøysund	3,6 10,9 20 38,8 47,5.
112. Valanhamn, Kvenangen	2,4 12,4 20 31 41,6 48,9 56 58,1.

113. Harstad	8 12 20 35 47 57 (aneroid).
114. Oldervik, Ulsfjord	7,3 11 20,5 34,5 37,5 44,5 46,8 52,8.
115. Alteidet, Kvænangen	2,5 11 13,3 20 24 34,9 45,7 52,9 57,9 77,6?.
116. Kanebogen, Trondenes	8,1 12,7 20,8 37,3 48 58,5.
117. Klauvnes on Uløy	7,8 20,4 31,4 48,3 55,2.
118. Stonglandseidet	20,7 49.
119. Sør-Lenangen	10,2 21 37,7 45,7 53,8.
120. Vassvik	11,4 20,9 51,2.
121. Kraknes, Rossfjord	10,8 21 34,6 46,5 57,9.
122. Selnes, Ulsfjord	10,5 20,8 21,3 30,1 43,6 51,9 100?.
123. Bukskin, Gisund	7,4 12 21,4 50,6.
124. Bakkeby, Malangen	11,1 21,5 40,3 50,2 58,5.
125. Bjorelvnes, Gisund	10,6 21,2 52, 3 56,1.
126. Bundjord, Gisund	11,5 21,5 36,5 47,2 55.
127. Holmeslet, Tromsøysund	7,7 21,5 31,6 41,2 49,5.
128. Laukslet, Ramfjord	8 22,2 53,2.
129. Bakkelund, Oksfjord	2,1 7,1 12,9 21,9 34,9 60.
130. Bakkeby, Nord-Reisa	4,9 20,3 21,9 31,4 39,9 53 55 61,4? 64,9.
131. Storvik, Malangen	6,3 12 13,9 22,5 37,8 48,7 50,4 60,3.
132. Nålelv, Burfjord	6 15,1 22,7 33,6 61,9 65,8 79,1.
133. Vikstrand, Senja	12,5 23 58,3.
134. Mortenhals, Malangen	6,5 11 12,4 23,2 52,1 66 69,2 71,2.
135. Sætra on Uløy	9,3 23,1 41,4 39,4 51 62,8?.
136. Kilbotn on Hindøy	7,7 8,7 12,7 22,8 35,9 37,8 45,5 47,5 59,1 61,5.
137. Vinje on Dyrøy	8,5 26,5 46,3 61,5.
138. Breivik, Ulsfjord	10,6 21,6 40,3 51,3 62,9 77,7.
139. Kongsvik, Tjellsund	7,5 12,5 24 38 52 58 (aneroid).
140. Haugrud, Malangen	11,4 12,8 23,4 27,1 37,9 39,1 52 58,2 62,1 75,9.
141. Storslet on Uløy	9,5 21,8 40,1 51,3 62,5.
142. Langhamn on Dyrøy	9,5 23,6 60,6.
143. Storvik, Nord-Reisa	3,6 9,5 22,4 34,7 38,6 57 62,3 73,9 79,9 91,5?
144. Skogen east of Finsnes	9,6 18,7 35,2 48,7 51,6?.
145. Sandnes, Kvænangen	2 3,4 6,1 13,1 20,2 23,4 38,7 57,6 66,6 69,9 84,1?.

146. Nyheimen, Malangen	12,9 23,8 38,4 53,4 64,4.
147. Rotsundelv, Rotsund	3,8 6,4 10 24,4 41,2 51,9 60 62,3.
148. Hamnes on Uløy	10,3 23,9 42,3 53,1 60,1 63,3.
149. Ulvik, Tjellsund	7,4 12,1 24,3 41,2 59.
150. Andersdal, Balsfjord	12,8 24,4 51,6 58,9.
151. Sakrijord, Ramfjord	8,3 23,2 33,9 45,8 59.
152. Målsnes, Malangen	13,5 14,7 24,5 33 49 55 64 80,6.
153. Sørvik on Hindøy	9,2 13,5 24,9 39,5 45,4 51,8 60,1 62.
154. Lunneberg, Sør-Reisa	14,2 25,3 48,8 60,9 76,5.
155. Gausvik on Hindøy	8,5 11,6 13,6 18,2 25,2 40,3 41,3 55,3 59,6 66,7 69,9?.
156. Stensland, Tjellsund	8,3 13,9 24,8 38,8 43,2 56,8 68,5 71,3.
157. Skogan, Tjellsund	7,7 13,6 25,4 41,5 44,1 57,5 72.
158. Skarmok, Ulsfjord	7 13,5 22,4 28,3 35 43,8 58,2 69,1.
159. Strømsnes, Sørfjord	6,3 9,8 11,9 16 25 36,2 44,5 58,8 65,2 72.
160. Skogli, Balsfjord	14,2 25,3 41,2 50,4 61,3 63,3.
161. Horvik, Tjellsund	8,4 12,4 25 38,6 58 80,5?.
162. Furstrand, Vågsfjord	14,2 25,1 64,1.
163. Hammervik, Lyngen	10,4 16,7 25,1 38,6 41,2 43,5 53,7 62,8 64,4.
164. Tømmerbukt, Kvænangen	2,8 5,2 7,5 10,1 11,9 14,8 18,1 24,9 26,2 36,7 43,5 47,5 50,4 53,8 56 59,6 62,5 64,6.
165. Sandtorg, Tjellsund	8,7 13,8 25,4 39,6 42,4 56,9 66,7.
166. Malangseidet, Balsfjord	7,6 14,7 26,2 40,8 56,4 61,8.
167. Sandstrand, Vågsfjord	8,4 14,5 26 27 45,3 47,4 59,2 65,4 67,9 73,7.
168. Bakland, Tjellsund, east	8 14,6 26,2 45,7 59 75,7.
169. Engenes, Lyngen	10,7 25,9 33,7 45,1 55,8 66.
170. Kastneshamn	10,5 26,4 63 68,4.
171. Badderen, Kvænangen	4,2 7,9 13,8 19,8 26,3 32 36,3 44,7 50,1 60,9 68,8 75 88?.
172. Sommerbukt, Sørfjord	12,6 15,5 26,4 48,2 59,8 74,1 75,8.
173. Smørskar, Sør-Reisa	7,8 14,4 15,1 26,8 51,8 65 67,4 81,9.
174. Naustvik, Sør-Reisa	14,6 15,6 26,5 53,6 67,5 87,7 114,7?.
175. Elvebakken, Astafjord	14,5 27,6 44,8 56,8 72,5 74.
176. Renså, Astafjord	15,7 26,2 27,9 42,3 43,6 56,6 72,3.

177.	Gottesjord, Sør-Reisa	15,1 19,2 25,8 26,9 53,2 68 83.
178.	Sørfjorden, Malangen	4,2 6,2 9,3 14,4 28 61,9 64,6 75,9 87,2.
179.	Tytebærvik, Kjosen	7,1 13,7 27,5 45,3 48,1 60 61,8 75,5.
180.	Rødberg, Tjellsund	8 10 14,4 27 45,7 59,7 74,7 76.
181.	Svartnes, Balsfjord	14,9 27,6 42 53 66,5 67,5?.
182.	Skagstad on Engeløy	3,1 5,6 11,3 17,3 20,1 23 25,1 28 35,3 37,4 41,3 47,2 50,4 52,1 58,5 61,6 68,4 92.
183.	Nygård, Astafjord	15,1 28,5 38 44,9 58,4 74,7 .
184.	Stornesbukt, Sørfjord	6,9 15,4 25,5 27,3 29,3 50,4 62 64,7 75,5 79,5.
185.	Myklebostad on Engeløy	3 7,2 17,8 29,6 30,6 39,4 46,3 63,7 68.
186.	Lyngseidet, Lyngen	13,6 28,8 47,8 49,3 63,2 73,6 76,2.
187.	Olderelv, Lyngen	3,9 10,5 13,6 29 48 62,1 75,7.
188.	Skognes, Sørfjord	8 15,6 17,6 27,8 42,7 51,4 63,4 65,8 80,1.
189.	Storelv, Sørfjord	7,9 15,2 17,8 24,8 27,2 42,2 53,4 59,8 74,8 83,4.
190.	Ørnes, Lyngen	13,8 29,2 49,8 65,9 78,1.
191.	Lakseidet, Malangen	12,8 26,2 72,8 89,4.
192.	Laksvassbukt, Balsfjord	15,3 28,4 67,6.
193.	Balteskar, Grovfjord	16,6 30,9 46,8 60 77,6.
194.	Middagsbukt, Balsfjord	3,5 9,5 15,7 30 48,4, 66,9 78.
195.	Bogneset, Tysfjord	3 13,2 19,7 31,9 43,5 48,8.
196.	Porsøya, Ofoten	13,3 30,1 48,2 64,1 67,4 74,9 79,2 84,3.
197.	Leirvik, Sagfjord	3 14 21,6 30 31,5 40 55 71,8.
198.	Repvik, Efjord	3,4 6,2 14 17 24,6 25,6 28 33,8 39,3 53,7 63,4 67,3 78.
199.	Vika on Vega	2,5 6,8 18 27,1 37,8 41,4 63,2 65,9 81,4 98,5.
200.	Kroken, Lyngen	14 16,3 31,2 50,7 64,3 81,7.
201.	Djupvikpollen, Sagfjord	3,3 6,6 17,3 24 31,2 47,7 55,8 82,4.
202.	Elvebakken, Balsfjord	4 8,6 12,3 15,1 18 30,9 37,6 45,8 50 62,4 73,1 80,5.
203.	Brennsundvik	2,8 6,9 13,5 14,6 19,2 21,2 37,9 49,8 60,7 63,7 68,9 70,9 78,9 92,7.

204. Grov, Grovfjord	6,3 9,6 12,8 19,7 26,4 31,6 46,4 63,1 64,7 80,7.
205. Årsandvik, Grovfjord	9,8 16,2 32 47,7 68,5 81,2.
206. Mælen, Balsfjord	3,6 7,6 11,6 15,2 18 25,2 32,8 52,4 72,2 79,4 81,3.
207. Lien, Ofoten	10,4 14,7 31,9 51,7 54,2 66 81,8.
208. Tennes, Balsfjord	13,4 17,6 31,7 78.
209. Lilandskaret, Ofoten	8,6 14,6 22 32,5 51,9 68 71 82,7.
210. Gullvik, Sagfjord	3,1 12,8 23,4 32,4 39,4 47,4 65,7 79,9 83.
211. Kjær, Tysfjord	3,4 6,5 18 21,6 29,4 37,1 40,9 53,6 64,8 83,9.
212. Skrovkjosen, Tysfjord	3,2 6,8 12,7 19,4 27 32 43,4 46,5 66 69,7 73,5 83,8 100.
213. Dalen, Lyngen	14,8 29,8 32,6 43,5 53,8 69,2 71 82,6.
214. Djupvik, Ofoten	9,3 10,3 15 33 52,3 61,7 68,2 85,3 87,3.
215. Leinesleira, Leikanger	2,9 5,8 13,9 22,4 28,3 35,4 37,6 49,3 58,8 68,9 76,7 82 94.
216. Soløy, Lavangen	8,9 17,3 30,7 34,6 48,3 52,6 70 83,6.
217. Balkjosen, Folla	2,5 5,2 10,3 16,5 22 34,6 48,8 66,3 70,9 83,5 99,6.
218. Storsteinnes, Balsfjord	6,8 12,9 16,3 23,6 33,6 36,2 49 72,2 80,2 83,6.
219. Årstein, Gratangen	4 10,7 18,7 23,7 27,4 34,4 37,9 49,3 58,3 61,3 82,2 85,5 93,7.
220. Skjenken, Folla	6,1 19,5 21,7 35,3 38 48,9 59,9 94,2.
221. Bakken, Ofoten	8,5 14,2 31,6 33,8 53,1 55,3 70,5 78,5 86,3.
222. Nordfold, Folla	3 6,7 15,7 21,7 27,5 38,6 54 60,1 69,3 84 95.
223. Bjørn on Dønna	6,7 10,7 17 23,5 29,2 37,6 51,8 60 73 75,9 79,4 92,3.
224. Marknes, Balsfjord	16,9 32 34,8 76,1 83,6.
225. Kobbenes, Efjord	3,8 7,4 12,7 18,6 23,5 25,2 28,9 38 40,1 43,4 57,3 68,2 70,2 75,1 82,5.

226. Elvesletta, Ofoten	7,6 14,5 30 31,5 37 51,1 71 82,4 90.
227. Kjerringøy	3,1 6 13,5 21,2 39,6 51,9 60,7 80 96,2.
228. Gratangsbotn	6,7 8,3 14,9 18,7 26,4 46,8 49,6 63,2 71,6 74,9 79,6 93,3.
229. Brattfjord, Folla	2,1 4,9 11,7 19,9 27,2 39,2 53,8 71,3 83,2 96,7 106,3?.
230. Eidet, Folla	5 6,9 15,7 22,4 31,2 44,8 50,8 75,3 82,6 96,7.
231. Heldal, Folla	3,5 9 12,6 17 22,5 26,5 28,5 38,6 42,1 45,3 52,6 62,8 75 85,9 100.
232. Lien, Sagfjord	3,4 11 15,4 18,1 22 24 32,5 49,2 62,8 70 76 87,7.
233. Mjelde	5,9 14,2 21,2 39,9 51,8 59,5 68,2 80,7 95,3.
234. Hopen, Folla	3,3 6,2 8,3 16,2 23,7 35,3 37,5 52,2 63,5 72,1 83,7 99,9 102,2.
235. Nord Fugløy	3,1 6,3 9,2 12,1 16 23,8 27,6 35,4 39,4 57 69,2 81,7 88,7.
236. Kirknes, Lyngen	7,4 10,7 22,4 28,7 33,9 52,4 56,3 70,2 78,4 85,5.
237. Movik, Folla	3 7,7 15 21 24,4 34,4 48,5 50,2 59,3 67,6 79,3 82,7 97,2.
238. Stefjord, Tysfjord	3 5,1 7,5 12,6 15,8 25,4 33,7 46,7 54,7 65 66,7 79,2 89,7 100,2.
239. Stavnes on Åmøy	2,7 9,8 18,2 29 38,1 48,1 56,8 60 70,3 85,3.
240. Øyjord, Folla	7 10,2 13,2 16,8 20,1 26,6 39,2 47 53,2 58,4 68,5 82,7 85,1 99,1.
241. Fossland on Tomma	3 10,6 15,1 20 26,8 31,1 38,9 40,7 47,1 51,6 60,8 62,8 69,8 79,3 84,8 91,9.
242. Reinvik, Folla	2,8 4,8 9,5 17 24,6 33,5 36,5 43,5 49,8 52,6 62,4 85 91,3.
243. Fagervik	7,5 14,3 21 27,7 42,5 50,7 71,2, 89,5 95,5.
244. Stavfjord, Folla	4 10 15,7 20,1 27,5 39,2 45,2 53,5 69,1 71,9 84 87,2 104,4.

245. Hestun on Hamnøy	2,8 7 9,5 15 18,6 38,3 56,4 62,1 64,7 86 108.
246. Straumen, ytre, Tysfjord	3,3 7,6 12,7 14,7 21,6 25,3 31,2 37,1 40,1 45,3 54,3 56,8 75,1 105,1.
247. Vevelstad	3 10 14 19,4 25,3 30,4 40,8 70 89,1 109.
248. Brattland, Lurøy	3,4 10,9 16,5 19,6 33,9 39,7 45,6 56,2 62,5 69,5 87,5 90,4.
249. Mosvoll, Meløy	3,6 5,9 8,9 16,9 27 34,1 37,9 41,7 47,7 49 51,1 54,2 62,3 69,4 89,6.
250. Bjørnsvik, Folla	3 7,9 13,8 15,4 21,5 28,3 40,5 54,5 72,8 84,1 103.
251. Kvarsvik, Gildeskål	3 12,7 23,1 37,8 40 47,5 68,3 76,8 86,1 93,7 (-1?) 96,7?
252. Riksen on Hannesøy	2,5 11,3 21,3 28 37,8 49,1 61,2 76,6 81,8 83,8 97,9.
253. Botnfjord, Folla	7,7 12,9 15,4 (-0,8?) 22 42,5 55,8 69,9 87,5.
254. Lysfjord	5,7 14,6 17,4 24 31,7 45,3 50 53 56,7 62,7 84,9 92,5 98,4 103,9.
255. Eide, Velfjord	6,7 14,5 18 19,6 40 57,5 61,2 72,2 87,9 101,2 107,7 121,6.
256. Kjeldal, Bjerangsfjord ...	6,4 15,4 19,9 21,9 30,7 40,5 69,3 80,5 90,7 99 108,6 118?.
257. Visthus, Visten	6 11,8 22 35,4 38,5 42,5 53,2 64,5 77,5 88,5 105,9 122,9.
258. Sørfjord, Rødøy	3,1 7,1 10 22,1 24,2 28,4 37,7 60,7 68,9 87,1 100.
259. Sandåg, Glomfjord	3 8,8 14,8 30 47,7 66,6 73,5 82,7 92,6.
260. Breivik, Tjongsfjord	3,3 8 10,4 20 29 32,6 41,6 49,2 58 72,8 92,6 100,4.
261. Storvik, Gildeskål	3,1 11,5 22,1 26,9 41,4 64,1 75,6 94,5.
262. Våtvik, Melfjord	4 10,1 17,6 21,6 (+ 1 ?) 32,9 43 49,7 55,9 70 84,2 (0,5?).
263. Laingen, Vefsen	3,5 7 13,6 21,6 22,6 32,2 40,7 53,3 60,1 68 75,6.

264. Musken, Tysfjord	3,3 8,1 14,8 28,6 36,2 41,9 49,2 57,2 66 78,7 102,3.
265. Sjunkfjordbotn, Folla ...	8,4 10,2 15,5 21,6 30 40,6 55 70,2 78,2 108.
266. Malm in Vik	3,5 6,8 20,1 22,1 28,4 41,3 65,5 114,6 131,5.
267. Botnet, Bindal	5,9 18,1 35,2 41,9 46 62,4 73,5 85,9 101,5 103.
268. Sandnes, Nesna	3,4 6,9 15,3 33,6 36,7 40,4 77 84,7 88 98,5 109,1.
269. Gjervikvalen, Rødøy	3,1 6,2 8,2 12,6 21 25,3 42,9 49,5 56,6 60,2 75,8 81,8 99,4.
270. Moen, Gildeskål	3,7 7 9,2 12,7 19,7 21,5 37,4 41,4 52,8 56,7 63,5 83 86,9.
271. Holand, Holandsfjord ...	3 3,7? 10,2 20,3 31,5 43,2 54,7 60 78,4 80,4 92,3 101,4 104,4.
272. Bjørnå, Visten	9,4 22,4 38,1 44,4 47 49,9 67,6 84 95,1.
273. Leiren, Leirfjord	4,4 7,7 9 13,2 17 20,9 31,6 39,1 49,4 54,3 60,3 70 73,3 80,6 88,5.
274. Sørnes, Vefsen	3,9 14,4 21,8 28,1 34,3 37,9 43,7 54,1 64,8 75 92,8 96,4 103,6.
275. Tuv, Bodin	3,6 8,6 14,9 22,4 36 42,2 49,8 61,7 82,5 84?
276. Kalvik, Folla	8,4 15,4 25,9 40,3 43,4 51,8 61,5 82,4 100,3 118,4? 126?
277. Hestvik, Folla	8,9 14,4 25,7 40,2 43,2 55,4 85,4 99,3.
278. Mørsvikbotn, Folla	2,6 5,2 7,3 10,3 17,7 26 44,8 53,4 62,2 74 87,6 100,1 106,3.
279. Engan, Folla	8,9 16,8 27 42,4 53,9 59,7 62,8 77,5 86,2 104,6 106,2.
280. Glomfjord	11,8? 13,8 17,3 27,3 42,6 68,6 101,5 146,3?.
281. Røsvik, Folla	7,8 8,8 14,6 23,1 42,5 54,6 71 98,6.
282. Botteløra, Holandsfjord	3,5 8,8 15,8 22,1 43,7 64,5 104,9 108,7?.
283. Hommelstø, Velfjord ...	6,6 16,8 31,4 45,4 57,4 63,2? 64,6 70,6 90,5 108,5 121,9.

284. Kvarv, Folla	3,3 8 13,4 25,6 31,7 41,5 44,5 57,3 72 86,4 87,4 104,3.
285. Sørfjordmoen, Folla	5,5 16,4 25,3 41 61,9 85,5 109,6.
286. Vasås, Bindal	5,9 12,6 18,4 38,4 42 45 55,3 57,3? 68.
287. Hellemobotn, Tysfjord	3,9 8,7 14,5 23,6 29,4 40,9 45 63.
288. Stiauren, Sjona	3,2 5,8 12,8 16,7 25,9 38,3 39,3 78,9 89,4 96,7 104,6.
289. Melfjordbotn	2,9 6,2 11,7 15,8 22,6 33,9 35,4 42,7 45,7 52,1 62,5 72,7 79,1 83,6 100,4.
290. Torkelseng, Folla	9,4 29 45,9 54,2 57,1 69 74,1 97,5.
291. Søfting, Vefsen	2,3 6,8 8 17,5 22,6 29,1 45,6 52,8 67,8 81,2 92,4 103,8 114,2.
292. Dokmo, Beiarn	5,5 16 21,4 26,9 32,3 35,2.
293. Sjonbotnet, Sjona	3,6 8 13,7 17,9 24 31,6 34,5 45 59,2 68,5 108,6.
294. Børjeør, Velfjord	9,6 15,5 22,3 32,6 39,9 47,8 57,4 64,8 75 76,6 85 95,4 114,1 125,3.
295. Breivik, Salten	4 9,5 23,6 26,6 33,4 38,9 46,7 52,2 56,1 64 68,3 76,2 86,8 105,4 112,5 120,6.
296. Halsøy, Vefsen	9,6 20,5 47,3 56,7 68,9 70,4 80,8 94,3 102,8 117,7.
297. Lillegården, Folla	2,4 10 15,3 26,6 44,7 59 74,8 105,7.
298. Sukhoi Noss, Novaya Zemlya	2,6 19,5 64,6 75,7 82,4 84,5 87,9 107,9 115,7 141,1 156,1 175,6 179 203.
299. Utnes, Utskarpa	11,6 27,4 38,4 43,4 47,9 68 75,4 94 107,2? 117,7.
300. Elsfjordstrand, Rana	7,5 17,5 25,6 29,4 42 44 55,4 64,6 80 87,6 101,4 121,7 131,1?.
301. Misvær, Salta	4 9,7 16,5 25,4 44 62,3 95,3 104,4 108,3 115,7 117?.
302. Storjord, Beiarn	16 29,1 35,9 44,8 59,7 66,1 71,5 78,5 98,5 102,3.
303. Lande, Tosen-Bindal	6,5 20,9 34,3 45,5 56,1 63,2 95,4 104.
304. Ravnå, Nord-Rana	59,4 70 74,4 79,7 88,6 98,4 104,6.

305. Osbak, Beiarn	22 31,9 36,6 39,3 49,3 54,8 104,7 110,7.
306. Tolå, Beiarn	43,4 50,8 69,3 94 109,6 116,7 121,6.
307. Setså, Salta	1,5 2,9 4,4 9,5 17 26,4 34,5 46,2 59 91,1 105,5 126,1.
308. Weber Ridge, N. Z.	2,9 13 31 42,2 52,3 61,3 68,8 76,5 81,5 99,5 111,9 117,9 132,3 150,6 156,2 171,3 215,3 218.
309. Serebryanka, N. Z.	3,9 10,5 18,2 30,9 42,2 52,2 68,5 79 102,5 118,2 137,6 152,7 156,3 175,5 198,7 270?.
310. Ytteren, Nord-Rana	7 16,8 24,5 34,5 39,9 43,3 64,5 82 113.
311. Bjørnå, Nord-Rana	54,1 54,7 67,6 72,4 79,8 81,2 83,9 93,2 100,4 105,1 116,1 119,6.
312. Blåfjell Basin N. Z.	2,8 14,8 21 32 34 37,6 54,2 72 83,2 95 101,7 116,5 121,4 133 165 201 220.
313. Svartishei, Nord-Rana	53,9 63 76 85,1 95 98,5 106,1 116,9 131,4.
314. Nordenskiölds Plateau, N. Z.	1,9 19,1 31,3 53,8 70,8 111,5 117,5 141,9 204,8.
315. Øivindgård, Saltdalen	34,6 47,6 55,6 71,6 94,4 113,6.
316. Rusånes, Saltdalen	49,3 55,9 66 70,2 72 76,1 87,9 95 111 130,8.
317. Pomorskaya, N. Z.	3 14 25,4 32,3 40 42 56,5 72 82,9 98 107 115 121,9 135 138 156 159,6 197 215.
318. Bergulnes, Saltdalen	82,6 84,9 88,7 92 94,1 99,8 105 115 125,5.
319. Gribovii, N. Z.	2,5 14,5 20,9 31,1 32,4 42,8 43,8 57,8 72,3 81,7 88,2 99,4 110 119 121,9 144,7 153,6 158,5 184,4 212,9 240 270 310 325 350 370.
320. Archangel Bay, N. Z.	3,2 11,7 23,3 36 48,9 58,8 66,4 73,1 78,5 90 103,4 106,9 127,2 145,3 164,3 169,5 186,9 203,2 218,9 238,9 271,8 295 305 315 322.

4. THE UPPER MARINE BOUNDARY

If following the shore lines from outlying islands eastwards along sounds, fjords, and valleys it appears that gradually lower and younger lines represent the upper marine boundary. In that way the shore lines give information of the recession of the ice front, and were only the material of measurements sufficiently good and detailed it should have been possible to reconstruct the stand of the ice border during the engraving of every single shore line. So complete a material is not yet at hand, but as it is, the ice front can be reconstructed for some of the best fixed shore lines or bundles of lines. The n-line marking the upper marine boundary at Hasvåg is sharply engraved on the outside of a large strand wall of cobbles and boulders of medium size. The locality lies open to the sea, and the breakers have once had a free play there. The shore line is situated 51,8 m above the present sea level, and the top of the wall rises to 52,5 m. Farther to the south on the same island the surf may have reached to about 60 m, but no shore line proper is there to be found. In Nordland this line has been pointed out at Skagen in Bø on the west coast of Langøy 35,8 m o. s. l., on Vedøy in the Røst group at 48,7 m, and on Trenyken in the same island group at 39,9 m above sea level, on both these islands at the entrances of caves formed by the sea. The western shores of Flakstadøy have not been surveyed, but it is likely that the n-line will be found also there. On pl. III the most westerly line is intended to show the supposed maximal stage of the ice front cf the last ice sheet. When the n-line was engraved the ice front may have retreated somewhat from this border line.

At Toften on Langøy and at Meltefjordnes on Sørøy it is the next younger shore line, the m-line, which is marking the upper marine boundary. At Bleik and Eggum on Vestvågøy the marine boundary is marked by l, at Vik on the same island, at Bø and Risøyhamn on Andøy by k, at Fuglnes near Hammerfest and at Ganslåt on the outer part of Malangen fjord by i_1, at Vengsøy on the western side of Kvaløy by i, at Rekvik on the western coast of Kvaløy and at Finnsæter on the western shore of the Kvæfjord by h_3, at Gresnes farther south on the same shore, at Fritsvoll on Malangenfjord, and in Jøkelfjord by h_2, at Vasstrand and Ersfjordbotn on the west coast of Kvaløy and in Hersfjord on the northern part of Langsund by h_1, at Alteidet by h, at Badderen near the head of Kvænangenfjord by g_1 etc.

According to what has been stated above the shore lines from n to h_3 have only been pointed out from the Lofoten islands northwards. It is therefore reason to believe that while these lines were engraved there was an ice barrier off the coast of Helgeland and Salta. The sea must have washed a continuous ice front all along this stretch, likely forming, by degrees, a wide bay in the Vestfjord where an eventual stream along the ice front had to turn to the northwest for rounding the west point of the Lofoten islands which then stood as a continuous wall to the north. That such a bay must have existed is proved by the fact that at Skagstad on the north coast of Engeløy in Steigen the shore line g_4 has been pointed out as the oldest line on the coast of Nordland, south of Lofoten, 92 m a. s. l.

It must be supposed that the melting of the ice started at the outer border just on account of a relatively warm north-going stream. As long as the sounds between the Lofoten islands were blocked up by the ice this stream must round the outer part of Lofoten. Therefore the front south of Lofoten was more exposed to melting than the ice in sounds and fjords farther north where it was protected against melting by outlying islands and was keeping its ground for a relatively long time. Still farther north there was free front once more between Vannøy and Sørøy, and therefore this part of the open sea and the adjoining sounds and fjord became free from ice as the first ones in Northern Norway as the ice sheet was not so thick there.

In the time next after the engraving of the m-line a melting period seems to have been replaced by a cold period, for on Andøy there have been two stationary stages of the ice front, one along the west coast where highlands did not bare the way to the coast, and another farther to the east, crossing the lowland just west of Bjørnskin chapel, touching the middle mountain party at its eastern projection and continuing northwards west of Dverberg church, there called the Kirkra. At the same time the sea surface seems to have been in eustatic rest, as will be pointed out later. During the engraving of the lines l to k even an eustatic sinking may have taken place. After the ice front had retired from the Kirkra stage the recession must have been continuous for a length of time, for no moraines have been found till in the sounds between the islands and the mainland, and the sea may also have been continuously rising till a new standstill of the ice front took place and with it the engraving of the shore line g_2.

During the melting period just mentioned the Sørøysund, the Rognsund, the Stjernsund, and the Kvænangenfjord became free from ice. The Lyngenfjord got ice free to beyond the Rotsund, the Ulsfjord to Skarmok, likewise the Langsund, the Kvalsund, the Grøtsund, and the Malangenfjord, but the Tromsøysund and the Balsfjord were still filled by the ice. The ice in the sound between Senja and the mainland was melted from the north, from the outer part of the Malangenfjord, and at some later date, near the end of the melting period, the inner part of the Vågsfjord and the Tjellsund seem to have been opened, but not yet the Ofotenfjord. To the south of this fjord the western part of Hamarøy and Steigen may have been free from ice, but from the mouth of the Foldenfjord southwards there was still a continuous ice front off the coast.

5. THE TROMSØ-LYNGEN STAGE OF THE ICE FRONT

The melting period above mentioned was succeeded by a cold period which brought about a stationary stage of the ice front, the Tromsø—Lyngen Stage, marked by the best developed moraine series in Northern Norway. Moraines likely belonging to this series are to be found at the heads of Alta, Kvænangen, and Nordreisa fjords, at Slottet on the Lyngenfjord just south of the Rotsund, and at Skarmok where the moraine is cut by a stream leading from the Ulsfjord to the Sørfjord. A fine terminal moraine crosses the Breivikeid near the Ramfjord as a continuous ridge. On the east side of the Tromsøysund and in the town of Tromsø two ridges are to be found. The foremost ridge can be followed continuously across the Tromsøy. On the east coast of Kvaløy west of the Sandnessund the moraine series is represented by a thick layer of moraine material on the lower part of the mountain side westwards to the Kallfjordeid. Farther south it is once more a single ridge, rising from 50 m to about 200 m above sea level, which can be followed southwards to the Rystrøm (3 og 7). Likely the same series is to be found as a fine terminal moraine at Aspenes on the southern shore of the inner part of Malangenfjord and as fine ridges at the waterfalls Malangsfoss and Bardufoss in the Målselv district. At the head of the Salangenfjord is a great terminal moraine, and a similar ridge is to be found farther east in the Salangsdal. South of the Salangenfjord the moraine series cannot easily be followed, but according to the evidences of the shore lines the ice border must have crossed the Lavangenfjord and the Gratangenfjord at their mouths, and moraines near the head of the Grovfjord and at the mouths of valleys westwards to the Tjellsund are likely belonging to this series. South of the Ofotenfjord no moraines can be pointed out, but according to the shore lines forming the upper marine boundary it must be assumed that the ice front crossed the Ofotenfjord near the southern mouth of the Ramsund and the Tysfjord near its mouth, and from there it likely did pass the outer part of Hamarøy, Steigen, and Leiranger districts to the Brennsundvik on the mainland west of the mouth of the Foldenfjord. The shore lines g_2 and g_1 were engraved during this stationary stage of the ice front. The line g_4 has only been pointed out in a single place in Nordland south of Lofoten, at Skagstad on Engeløy, and on Vega g_1 is forming the upper marine boundary, cut in solid rock 98 m a. s. l., and the same line is surrounding the island Torget at the level of the well-known hole there through the Torghatten mountain. On pl. III the stationary Tromsø—Lyngen stage is named with the line G. From Kvænangen fjord to the Tjellsund the line G has been drawn along the moraine series mentioned above, from Ofotenfjord to the Foldenfjord its direction is based on the shore lines g_2 and g_1 as upper marine boundary lines, but from the Foldenfjord southwards it is only hypothetical. The one thing sure is that the ice front during that stage must have been situated off the coast of the mainland, but whether really stationary cannot be settled.

During the Tromsø-Lyngen stage there was a quite considerable local glaciation outside the stationary ice front. Former local glaciers were increasing, "dead" glaciers once more came in activity and new glaciers grow into being on the north side of the Hadseløy, on the southeastern side of Langøy and Sørøy, all of them places from which the inland ice had receded during the preceding melting period. It is therefore reasonable to suppose that also the inland ice proper was increasing at the same time and possibly in some places advancing.

Before the recession of the ice front from the Tromsø-Lyngen moraines took place a new melting period had set in, for on the east side of the Tromsøsund just opposite to the town of Tromsø a terrasse of glaci-fluvial material had been built 57 m a. s. l. at the right ice border while the ice still lay in the sound. During this melting period the shore lines g, f_1 and f_0 were engraved. In the Lyngenfjord

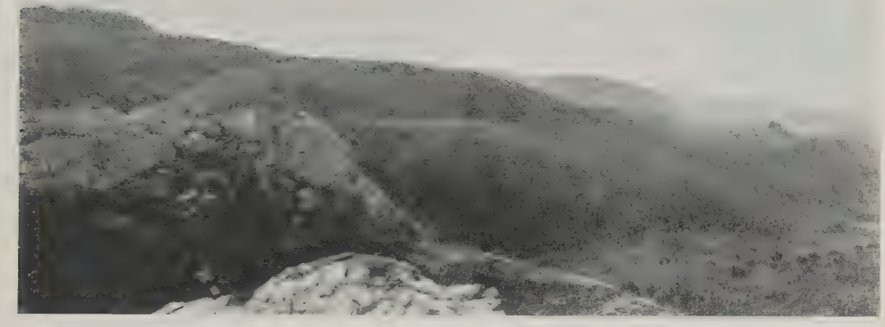

Fig. 18. A shore line in solid rock at Eidet in Vel-fjord
121,6 m a. s. l. Gr. phot.

the ice front seems to have stood firm for some time, for the lines g, f_1 and f_0 have not been found along this fjord, but as the f-line has been pointed out, the ice, however, must have been broken there in the later part of this melting period. The Sørfjord south of Skarmok became completely free from ice and likewise a greater part of the Balsfjord. In the Salta district the Sagfjord and a greater part of the Foldenfjord seem to have been opened. In the southern part of Helgeland the ice front had reached the mainland, for at Malm in Vik g is the uppermost shore line 131,5 m a. s. l., and at Eide on the south side of the outer part of the Velfjord f_1 represent the upper marine boundary. The f_1-line is in that locality sharply engraved in solid rock 121,6 m a. s. l. None of the younger lines below is so distinct and fine, and therefore it is to be supposed that the ice front must have been lying close by while this shore line was engraved. It seems to be a fact that no shore line has been sharply engraved in solid rock far-off an ice front (fig. 18).

During the melting period here mentioned the Velfjord became free from ice as the first fjord in Helgeland. With the then existing relative stand of the sea level this part of the coast lay open against the sea, and the ice in the Velfjord was therefore attacked in three places, at the mouth of the fjord, through a sound at Eide, and through a sound stretching northeast from Ursfjord to Hommelvik. From the mouth of the Vistenfjord northwards the ice front must still have been situated off the coast, for no one of the shores lines g, f_1 and f_0 are there to be found, and even on Dønna neither Vogt and

Rekstad nor the present writer have been able to find any shore line higher than 92—93 m which satisfies f—e, and from Dønna to past the town of Bodø all the shore lines up to now pointed out are younger than f. During the engraving of f—e there must therefore still have been a continuous ice front off the coast on this stretch. The lines f—e have formerly been supposed to be identical with the M-line in Troms fylke. This line was assumed to have been engraved during a stationary stage of the ice front or the fjord glaciers represented by a series of terminal moraines called the M-moraines (3). On Dønna the M-line (f—e) is strongly engraved in solid rock 92 m a. s. l., indicating that the ice front must have been close by while it was formed, but in Helgeland I do not know moraines belonging to this stage, and therefore the accurate course of the ice front cannot be fixed. The stage is designated by the line M on pl. III. This line is only to be regarded as a rough estimate as to its course within Nordland fylke. In Troms, however, its course follows the M-moraine series, which, however, ought to have been gone over once more in the field.

During a melting period following the stationary M-stage the inner part of the Lyngenfjord and the Balsfjord became free from ice. The ice melted away in the stem of the Ofotenfjord but not in its branches. It further melted away in the Sørfoldenfjord, in the Salta-Skjerstadfjord system, in the Ranafjord to about 8 km past Hemnesberget, and in the Vefsenfjord to past the present head of this fjord. The inland ice had during that period been reduced to isolated valley glaciers which at the end of the period by degrees passed into a new stationary stage at a moraine series called the M′-moraines (3), on pl. III noted M′. In Troms fylke a shore line engraved during the stationary M′-stage was called the M′-line and there believed to be a single line at a level about 83 % of that of M, but in Nordland this line seems to divide into a diverging bundle of at least three lines with d_2 as the middle line. The ice front stage M′ is more distinctly fixed than the M-stage.

During a new melting period the valley glaciers receded to a last stationary stage noted M″. Also to this stage a distinct moraine series can be pointed out corresponding with a sea level at about 64 % of that of M (f), in Troms fylke represented by one line called M″ which in Nordland fylke was substituted by a bundle of three lines with d at the middle.

After the M″ time the climatic conditions seem to have so much ameliorated that likely all ice melted away on our side of the frontier. It is the boreal time. Before this time the valley glaciers in Troms fylke seem to have been fed from the east through passes in the frontier, while in Nordland fylke the ice had been broken at an earlier date.

From the boreal time some finds of shells may be of interest. At Mælen near the head of the Balsfjord great specimens of *Cardium echinatum,* Lin. and *Zirphæa crispata,* Lin, have been found about 40 m above sea level. These two species are no longer living in sounds and fjords in this part of Norway, and the three living specimens of Cardium echinatum found by Sparre Schneider at Hillesøy were quite small. At Laberg on the southern shore of Gratangen fjord *Cardium edule,* Lin. has been found to 50 m a. s. l. and at the head of Balsfjord at 40 m a. s. l. In the valley of Trøsen river south of Skånland on the east side of the Tjellsund 30 m above sea level have been found among other shells *Homalogyra atomus* and *Cardium echinatum, abundantly* of *Macoma fabula* and some specimens of *Periploma prætenuis,* the last species only found in this locality in Northern Norway. In this place the b-line is situated 26 m a. s. l. It is likely that *Pinus silvestris* has immigrated to Northern Norway during this warm period. On Tromsøy roots and pollens of pine have been found in bogs, and in the Tromsdal on the east side of Tromsøysund I have found trunks and bark pieces of pine to between 250 and 300 m a. s. l. though at present not a single living tree of this species is to be seen there.

The boreal time seems to have been followed by a cold period in Northern Norway, at all events in Troms fylke. It is a fact that the shore line or bundle of shore lines called the Tapes level is so sharply engraved that this level was one of the two levels measured by Helland in Troms fylke. I have on a former occasion (7) drawn attention to two moraine series in some elevated valleys near the frontier in Troms, likely deposited by glaciers coming into being after the last inland ice had melted away. One of these moraine series was supposed to have been deposited in the atlantic time, described as a warm and humid period in temporate latitudes farther south. A humid period in the northern parts of our country would likely have had abundant snowfall in winter and wet summers without sunshine and warmth even if the middle temperature of the year was not exceptionally low. The said younger moraine series have not only been found west of the frontier, for Sjøgren has also found them within the mountains south and southwest of lake Torneträsk. Lofty cirques on the islands from Lofoten northwards are also pointing in the same direction. By examining fossiliferous shell material from occurrences on the Tjellsund, especially from the shell banks at Evenskjær, about three metres thick, I found in material from the lowest layers a fossiliferous mollusc fauna composed of about 60 % arctic species and 40 % boreal and lusitanic species whereas the upper layers had a fauna composed of about 60 % boreal and lusitanic species and only 40 % arctic species. There did not seem to be any discontinuance in the deposition, for samples taken from the middle of the banks had a fauna of transitional character (4). I have mentioned these facts in the hope that some one will be interested in these questions which ought to be more closely studied.

The shore lines c and b are nearly one in Troms fylke, the b-line, however, being the higher line in the greater part of the district, but c-line the higher line near the heads of the fjords. The c-line may have been engraved during the atlantic time contemporarily with the deposition of the lower layers of the shell banks. Then a warm period set in, the subboreal time. Glaciers melted away, a warm stream was running along the coast and a boreal-lusitanic fauna immigrated. A strong melting of the ice took place all over the globe, and the level of the sea rose quickly till the rising faded away near the level of the former c-line, and the b-line was engraved. This movement of the sea level is the Tapes transgression. In the b-line then lived a boreal-lusitanic littoral fauna, and the upper layers of the shell banks were deposited. In that way I believe that the observed facts are to be explained, and Tanner seems to have followed a similar course of thinking when dealing with the said transgression.

On the mainland south of the Ofotenfjord the b-line is everywhere situated above 27,5 m, and therefore c and b never coincide as the c-line is the upper one. None of them is so sharply engraved or so different from other lines that they easily can be identified there. Nor have moraines supposed to have been deposited in the atlantic time been found except in the vicinity of the Svartis. From the central part of this area a valley stretches in north westerly direction to the Beiarfjord, the Arstad- or Dokmodal. At the mouth of this valley is a terminal moraine with the form of an arch 30 m a. s. l. Far south in the Beiardal about 50 km from the head of the fjord some small moraines are also to be found likely of the same age as the Dokmo moraine. These moraines have been locally fed and must be younger than the M″-moraines, and therefore they may have been deposited in the humid atlantic time by advancing glaciers from the Svartis area.

In Troms is further a shore line which has been correlated with the younger one of the two moraine series above mentioned. In the northern part of Troms fylke it is the sole line below the b-line which is so sharply engraved that it cannot be easily overlooked during the field work. It is to be found at a level about 37 % of that of b, and would approximately correspond to a_3—a_4 in the diagram. More closely it cannot be indicated, for in Troms the said line no doubt is a double line, and the material from Nordland respecting the a-lines is not yet worked out sufficiently in detail. This line or bundle of lines has formerly been called T′ and the corresponding moraine series the T′-moraines, supposed to date from the subatlantic period (3). From Nordland fylke no moraines from this period are known.

6. CORRELATION BETWEEN NORTHERN NORWAY AND THE OSLO DISTRICT

To correlate the quaternary conditions of Northern Norway with those of the southern part of our country is not easily done and must in many ways be uncertain. As for the latitude, Bodø lies 7 degrees and Tromsø nearly 10 degrees farther to the north than Oslo. During the melting of the last inland ice the west and northwest coast must have been washed by the Gulf stream drift as now, while Kattegat, the Oslofjord, and Skagerak for a greater part lay outside this stream system and had a more or less rapid currant from southeast, a Baltic stream. Stationary stages of the ice front or periods of recession did not therefore of necessity be contemporaneous in so distant places as Oslo and Tromsø. Moraine series are especially difficult to correlate as they often partly owe their site to local conditions. Vogt, Tanner and the present author have been of opinion that the Tromsø-Lyngen stage was identical with the Ra stage in Southern Norway. This was possibly going too far, but it must, however, be reasonable to think that in spite of distance and local conditions an interplay between north and south had existed while the moraines were deposited even if some shifting of phases must be expected. To correlate the shore lines must, however, be safer because their forming was not only owing to the submergence of the land but still more to the eustatic stand of the sea level which was independent of local conditions and latitude. In order to find a connection between Southern and Northern Norway I have therefore inserted some measurements from the Oslo districts in my diagram. Pl. IV is only a direct prolongation to the right of pl. II in the same scale, and only lines of some interest have been drawn. In a paper by Holtedahl (12) a summary is given of the marine stages as follows according to Øyen: 1. The Mytilus stage from 220 m a. s. l. 2. The Portlandia stage from 205 m. 3. The Littorina stage at 175 m. 4. The Pholas stage at 142 m. 5. The Mactra stage at 95 m. 6. The Tapes stage at 70 m. 7. The Trivia stage at 47 m. 8. The Ostræa stage at 22 m and The Mya stage, the present stage. When these figures are inserted in the diagram where the b-line lies 70 m above the present sea level, then the 220 m line coinsides with f′, the Portlandia level is to be found between f° and f, the Littorina level coinsides with a line next below d_4, the Pholas level with d or close upon this line, the Mactra level with c_1, the Trivia level with a_7, the Ostrea level I with a_4, and the Ostrea level II with a_2. In spite of the fact that the levels by Øyen are not shore lines proper they still coinside fairly well with fixed shore lines except the Portlandia level. While the sea stood at that level *Portlandia arctica* was living near the ice front at the head of the fjord of that time.

In Northern Norway the climatic conditions were not fully arctic for there all sounds were open for passage of Gulf Stream water, but within the fjords glaciers were for a time stationary at the M moraines.

Holtedahl has studied the recession of the ice front on Romerike and he has pointed out the following stages: The Hauersæter stage, corresponding to a sea level at 205 m, The Dal stage, corresponding to a shore line at 202 m, and the Minnesund stage with a shore line at 194 m. The 205 m line seems to be identical with the f-line, the 202 m line with e, and the 194 m line with d_4. The Minnesund stage may thus be contemporaneous with the Littorina stage at Oslo. As the b-line has not been measured in the locality just named the figures cannot be inserted with absolute certainty but the error cannot be great.

The diagram pl. IV has been drawn in order to show how measurements from Southern Norway fit in a diagram only based on material from Northern Norway, but for closer discussing of these things the material at hand is too scanty.

IV. Equations of the Lines in the Shore Line Diagram. The Eustatic Stand of the Sea Level.

In order to fix the lines in the shore line diagram mathematically I have used a coordinate system with the zero line, representing the present sea level, as axis of abscissas. The vertical line limitting the diagram to the right cuts the b-line 59 mm above the zero line. Five hundred mm to the left of this vertical line another vertical line has been chosen as ordinate axis. In this coordinate system all the lines in the diagram are then represented by an equation of the form

$$y = kx + b.$$

The two vertical lines named above are cut by all the lines in the diagram which represent former sea levels. If the ordinates of the two cutting points are called y'' and y' then $k - \frac{y'' - y'}{500}$ and $b = y'$ and accordingly

$$y = \frac{y'' - y'}{500} x + y'.$$

y'' and y' can be taken out of the diagram with an exactitude of between 0,1 and 0,2 mm. By representing the lines in the diagram with equations it has been made possible to find cutting points between the lines by calculation instead of extending the lines to cutting and then measure the coordinates. The calculating method will give a safer result than the graphic method, for the lines are often cutting each other at a very acute angle and then it is difficult to measure the coordinates accurately.

For the n-line $y' = 122{,}7$ mm and $y'' = 305$ mm. The equation of this line is therefore

$$y = \frac{305 - 122{,}7}{500} x + 122\ 7$$

$$y = \frac{182{,}3}{500} x + 122{,}7$$

$$y = 0{,}3646\, x + 122{,}7$$

In the same way the equations of the other lines in the diagram have been found as the following table will show.

Line	y″	y′	Equation	Distance from the zero line
n	305	122,7	$y = 0,3646\,x + 122,7$	—100
m	299,9	119,9	$y = 0,3600\,x + 119,9$	—100
l	284,5	111,4	$y = 0,3462\,x + 111,4$	— 99,8
k_2	277	107,3	$y = 0,3394\,x + 107,3$	— 99,7
k_1	273	105,3	$y = 0,3354\,x + 105,3$	— 99,3
k	269,5	103,2	$y = 0,3326\,x + 103,2$	— 99,8
i_3	265	101,1	$y = 0,3278\,x + 101,1$	— 98,7
i_2	259,4	98,3	$y = 0,3222\,x + 98,3$	— 98,3
i_1	250,4	94,2	$y = 0,3124\,x + 94,2$	— 96,6
i	243,9	90,3	$y = 0,3072\,x + 90,3$	— 97,1
h_3	234,2	86,5	$y = 0,2945\,x + 86,5$	— 93,5
h_2	224,5	83	$y = 0,2828\,x + 83$	— 89,3
h_1	219	79,6	$y = 0,2788\,x + 79,6$	— 90,7
h	211,2	76,6	$y = 0,2692\,x + 76,6$	— 87,8
g_4	207	74,5	$y = 0,2650\,x + 74,5$	— 87,5
g_3	203	73,2	$y = 0,2596\,x + 73,2$	— 85,3
g_2	200,3	71,2	$y = 0,2582\,x + 71,2$	— 86,7
g_1	197,8	70	$y = 0,2556\,x + 70$	— 86,3
g	191	66,9	$y = 0,2482\,x + 66,9$	— 84,8
f_1	184	63,3	$y = 0,2414\,x + 63,3$	— 84,3
f_0	177	61	$y = 0,2320\,x + 61$	— 80,8
f	173	59	$y = 0,2280\,x + 59$	— 80,5
e	167,8	57	$y = 0,2216\,x + 57$	— 78,5
d_5	163,3	55,2	$y = 0,2162\,x + 55,2$	— 77,3
·	159	53,5	$y = 0,2110\,x + 53,5$	— 75,6
d_4	155,5	52	$y = 0,2070\,x + 52$	— 74,7
·	150,5	50,3	$y = 0,2010\,x + 50,3$	— 72,7
·	148,5	49,7	$y = 0,1976\,x + 49,7$	— 71,2
d_3	146,3	48,3	$y = 0,1960\,x + 48,3$	— 71,2
·	144, 3	47,7	$y = 0,1932\,x + 47,7$	— 70,6
·	141,7	47,1	$y = 0,1892\,x + 47,1$	— 68,7
d_2	139,1	46,5	$y = 0,1852\,x + 46,5$	— 67
·	137,1	45,7	$y = 0,1828\,x + 45,7$	— 66,2
·	134,5	43,5	$y = 0,1818\,x + 43,5$	— 67,8
·	131,8	42,5	$y = 0,1786\,x + 42,5$	— 66,8
d_1	129,6	41,3	$y = 0,1766\,x + 41,3$	— 66,8
·	127,4	40,2	$y = 0,1744\,x + 40,2$	— 66,6
·	122,8	39,6	$y = 0,1664\,x + 39,6$	— 62,4
·	121,6	39,2	$y = 0,1648\,x + 39,2$	— 61,8
·	119	38,2	$y = 0,1616\,x + 38,2$	— 61,7
·	117	37,5	$y = 0,1590\,x + 37,5$	— 60
d	113,2	36,6	$y = 0,1536\,x + 36,6$	— 57,4
·	111	35,5	$y = 0,1510\,x + 35,5$	— 57
·	109	34,4	$y = 0,1492\,x + 34,4$	— 57
c_4	106,8	33,4	$y = 0,1468\,x + 33,4$	— 56,5
·	102,6	32,5	$y = 0,1402\,x + 32,5$	— 53,4
·	100	32	$y = 0,1360\,x + 32$	— 51,4
c_3	95,5	31,6	$y = 0,1278\,x + 31,6$	— 46,7
·	90,5	30,3	$y = 0,1204\,x + 30,3$	— 43,5
c_2	89,3	29,5	$y = 0,1200\,x + 29,5$	— 44
·	87	28	$y = 0,1180\,x + 28$	— 44,3
·	84	27	$y = 0,1140\,x + 27$	— 42,8
·	81	26,5	$y = 0,1090\,x + 26,5$	— 40,3

Line	y″	y′	Equation	Distance from the zero line
c_1	78	25,3	$y = 0,1054\,x + 25,3$	− 39,4
·	74,5	24,2	$y = 0,1006\,x + 24,2$	− 37,4
·	72,4	23	$y = 0,0988\,x + 23$	− 37,6
·	71	21,7	$y = 0,0964\,x + 21,7$	− 37,4
c	68,8	21,2	$y = 0,0952\,x + 21,2$	− 37,1
b	59,5	22,5	$y = 0,0740\,x + 22,5$	− 22,9
·	55,2	21,4	$y = 0,0676\,x + 21,4$	− 20
a_9	53,5	20,8	$y = 0,0654\,x + 20,8$	− 19
·	50	20	$y = 0,0600\,x + 20$	− 16,6
a_8	46,7	19,4	$y = 0,0546\,x + 19,4$	− 13,9
·	44,4	18,2	$y = 0,0524\,x + 18,2$	− 13,8
a_7	41	17	$y = 0,0484\,x + 17$	− 12,3
·	37,9	17	$y = 0,0418\,x + 17$	− 8,6
·	36,4	16,5	$y = 0,0398\,x + 16,5$	− 7,8
·	33,7	15	$y = 0,0374\,x + 15$	− 7,8
a_6	31,3	14,2	$y = 0,0342\,x + 14,2$	− 6,6
a_5	26	13,5	$y = 0,0250\,x + 13,5$	− 1,7
·	23,7	12,8	$y = 0,0218\,x + 12,8$	+ 0,5
·	21,3	12	$y = 0,0186\,x + 12$	+ 1,3
a_4	19,8	11,7	$y = 0,0162\,x + 11,7$	+ 1,4
·	18,1	10,2	$y = 0,0156\,x + 10,2$	+ 1,3
·	15,8	9,5	$y = 0,0126\,x + 9,5$	+ 2,4
a_3	14,6	9	$y = 0,0112\,x + 9$	+ 2,7
·	13	8,3	$y = 0,0094\,x + 8,3$	+ 3,2
·	10,7	7,5	$y = 0,0084\,x + 7,5$	+ 2,5
a_2	9,2	6	$y = 0,0064\,x + 6$	+ 2,6
·	7,7	5	$y = 0,0054\,x + 5$	+ 2,6
a_1	5,5	3,6	$y = 0,0038\,x + 3,6$	+ 1,6
·	4	2,5	$y = 0,0030\,x + 2,5$	+ 1,3
·	3	2	$y = 0,0020\,x + 2$	+ 1,4
·	1,5	1	$y = 0,0010\,x + 1$	+ 1

a_0 The present sea level 0

As before said the cutting points can be found between two consecutive lines in the diagram by extending the concerned lines to cutting and then measure the coordinates of the cutting point, but these coordinates can be found more accurately by calculation when the equations of the lines are given. I have made such a calculation for all the lines of the diagram here reproduced, but a curve through the cutting points is crenelated and irregular and therefore it is not taken into nearer consideration. Some of the cutting points are, however, of interest. The coordinates of the cutting point (n, m) between n and m have been found to be (-608, 7, -99, 2), the cutting point (n, l) to be (-614, 1, -101, 2) (n, k_2) to be (-611, 1, -100, 1) and (n, k) to be (-609, 4, -100). The arithmetic medium of these figures is (-610, 8, -100, 1). A greater exactitude was not to be expected, and the coordinates of the point (n, m) has therefore been fixed to (-610, -100). This result transfered from the diagram to the map shows that the cutting line between the former sea levels n and m may be situated at about 100 m below the present sea level and between 72 and 80 km west of Andøy.[1]

Geologists studying the quaternary geology seem to agree that the forming of shore lines was owing to a cooperation between the isostatic movement of the land and the eustatic movement of the sea level. In a system of shore lines- and then also in a shore line diagram — the result of these two different movements must be enrolled as the sum of an isostatic and an eustatic component. The isostatic movement in the peripheric part of a depression must be to comprehend approximately as a rotation round a line, an axis — in a diagram round a point —, while the sea surface whether in rest or in movement must have been, broadly speaking, always parallel to the present surface. The isostatic movement was caused by alterations of the ice masses which lay over a depression, while the eustatic movements were due to climatic changes within all the glaciated parts of the earth, and they were, therefore, of a more general character. But since the result of the said movements has been registered as shore lines, in many places finely developed, it must be possible to find the approximate stand of the sea level while a former shore line was engraved, if only the search can be based on reasonable suppositions.

In conformity with the diagram pl. II the following suppositions have been made: The n-line is the oldest late glacial marine shore line and the m-line the next oldest shore line. The movement of the land surface in the peripheric part of the depression was a rotation round the point (n, m) = (-610, -100), regarded as a fixed point for some length of time. The former levels of the sea surface were always parallel to the present sea level. If the movement of the land had only been a rotation round (n, m) and no eustatic movement of the sea level had taken place all the lines in the diagram would have gone through the point (n, m). When not so doing it is due to the eustatic movement of the sea level.

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[1] In a diagram drawn after the method of Tanner the ordinates of the cutting points between lines only depend on the vertical scale of the diagram. If for instance a length of 1 chosen at will is inserted in the equations of the lines n and m instead of the 500 mms used between the two vertical lines y′ and y″ 1 is not to be found in the expression of the ordinate y of the cutting point, as it has passed out during the calculation.

One may then get an idea of the approximate stand of the sea level while the different shore lines younger than m were ingraved in the following ways:

1) By measurement on the diagram.

The diagram can be made to turn round an axis through the point (n, m), and the position of the zero line is fixed by a stretched thread before turning of the diagram. If then the different lines in due order are set parallel to the thread by turning round the point (n, m) the distance of the line from the thread in mm is the distance in meter of the former sea level from the present sea level. A line set parallel to the thread cuts the perpendicular line from (n, m) on the thread at a right angle, and the distance between the line and the thread is most easily measured on this perpendicular line.

2) By calculation.

The distance of a former shore line from the present shore line while formed can also be found by calculation. The equations of the lines in the form $y = kx + b$ must then be transformed to the form $\frac{y - kx - b}{\sqrt{1 + k^2}} = 0$. If the coordinates of the point (n, m) (- 610, -100) are inserted in this formula for x and y then the quantity

$$\frac{-100 + 610\,k - y'}{\sqrt{1 + k^2}} = a$$

where a is the distance of the line from (n, m). k and y′ are taken from the equation of the line in question. The distance of a line from the zero line (the thread), d, can be found by the formula

$$d = a - 100.$$

All the figures inserted in the last column of the table on page 54—55 have been found in that way, calculated by the aid of a sliding rule. On pl. V a point marks the stand of the sea level while the corresponding shore line was engraved. The horisontal distance between these points ought to have been in ratio with the lapse of time between concecutive shore lines, but as this time is unknown the distances have been chosen alike.

The curve pl. V shows that the sea level was nearly constant while the shore lines n to k were engraved. During this time the ice front was slowly receding across Andøy where two terminal moraine series were deposited, one along the west coast and another farther east of which the Kirkra is a part. The climate must therefore have been arctic with faint melting of the ice not only in Northern Norway but everywhere. After the ice had receded from Andøy there seems to have been a continuous melting period with a rise of sea level to g_3. While the ice front was stationary at the Tromsø-Lyngen moraines there was a sinking of the sea level from g_3 to g_1. After that time the rise of sea level has for the most part been even only with standstills from d_2 to d and from c_3 to c_1. From c to b is a considerable rise from -37 to -22 m, the Tapes transgression. During the subboreal time the sea level was once more quickly rising and reached the present level in the time between a_5 and a_4. From a_4 till the present time it seems always to have been situated higher than now but with a little sinking between a_3 and a_2 which may correspond to the subatlantic time.[1]

The curve pl. V shows what can be found by studying a shore line diagram and is in the first instance an attempt at bringing to light an eustatic component in a graphic reproduction and finding a method for isolating it. But if the graphic method is to be trusted, then the result must be to extend to the very system of shore lines. In a diagram each line represents a former sea level now brought out of its originally horizontal position by the rise of the land. The point (n, m) represents the boundary line of the depression. It is of some interest in this connection to note that the depth found for this point is of the same size as assumed by Tanner, -100 m.

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[1] As formerly mentioned the measuraments concerning the lines p to n_1 are deficient, either taken in places where the lines were indistinct from weathering or doubtful as measured with aneroid. If good shore lines they, moreover, ought to have been found in such places as Hasvåg, Skagen in Bø and on the islands within the Røst group, but no such lines have there been found above the n-line. Of that account I have not taken them into consideration as marine shore lines. But for making the account of the lines in the diagram as complete as possible the following remarks will be added:

Equation of the p-line: $y = 0{,}426\ x + 167$
—»— o_2 » $y = 0{,}410\ x + 155$
—»— o_1 » $y = 0{,}396\ x + 147{,}7$
—»— o » $y = 0{,}387\ x + 141{,}5$
—»— n_3 » $y = 0{,}381\ x + 136{,}5$
—»— n_2 » $y = 0{,}3746\ x + 132{,}7$
—»— n_1 » $y = 0{,}3672\ x + 127{,}4$

The cutting point (p, o_2) has the coordinates (-750, -152,5). The distances of the lines o_1 to n_1 from this point are as follow: o_1 -3,0, n_3 -3,5, n_2 -3,1, n_1 -4,2 m. The arithmetic means is -3,3.

It is likely that the sea bottom west of the said boundary line had been pressed somewhat up above its present level during the sinking of the land below the ice sheet. Such a ridge would then move eastwards again when the pressure within the depression decreased, and when approaching the boundary line then the sea bottom there would be rising and then once more sinking when the wave of uplift had passed. Such an uplift can, however, scarcely have taken place during the earlier part of the melting period as no irregularities have been found in the older part of the shore line system. When a wave of uplift had passed it must therefore have taken place while the later d-lines or c-lines were engraved, but this part of the diagram has not been so detailed worked out that any thing more positive can be said.

V. Connection between the Depth of a Depression and the Thickness of the Depressing Ice Sheet.

If supposed that the depressions of formerly glaciated parts of the surface of the earth were called forth by the weight of the ice masses which once lay over them it is evident that there must have been a certain ratio between the thickness of the ice and the depth of the depressions in case of equilibrium.

When the last Fennoscandian ice sheet had reached its maximal thickness the western ice border may have extended to the outmost line on pl. III. A greater part of the continental shelf was then, at all events, covered by the ice and therefore the sea had no touch with the land, and no shore lines could be engraved till the ice barrier had been broken somewhere or other. The uppermost shore line at Hasvåg, supposed to be the oldest late glacial marine shore line, could not, therefore, be formed till some time after the melting, of the ice along the ice border had set in. It is not necessary, however, to suppose that any rising of the land ere this had taken place, for it is likely that the inner masses which were to be pressed outwards during the sinking of the land surface offered so great a resistance that the subsoil had not come to rest till some time after the melting of the ice had set in and the recession of the ice front had started. Nor is it necessary to suppose that the sea level had moved off from its lowest stand essentially, for inferring from the present conditions it is likely that the melting of the ice set in at first just off the Norwegian coast.

If assumed as approximately correct that the n-line was engraved during the lowest stand of the sea level and the maximal depression of the land surface, the veritable depth of the depression in any place will be found by adding together the height of the uppermost shore line above the present sea level and the stand of the sea level at the time when this shore line was engraved.

If the thickness of the ice sheet in a place be H, the speciphic gravity of the ice 0,9, the height of the shore line in the same place is h, the isostatic component be q and the speciphic gravity of the inner masses be 3, the following equation of equilibrium can be used:

$$0{,}9\,H = 3\,(h + q)$$

$$H = \frac{10}{3}(h + q)$$

If now the stand of the sea level while passing from sinking to rising was 100 m below the present sea level and n the oldest shore line then the thickness of the last ice sheet during its maximum should be to calculate by aid of the formula

$$H = \frac{10}{3}(h + 100)$$

where h is taken out of the diagram in the place in which the thickness of the ice sheet is to be found. At Hasvåg h = 51,8 m and accordingly

$$H = \frac{10}{3}(51{,}8 + 100)$$

$$= 506 \text{ m}$$

In this way H can be found in other localities of interest. For some localities H is found as follows: Nyksund 437 m, Eggum 448 m, Værøy 497 m, Vengsøy 520 m, Greipstad on Malangenfjord 625 m, Strømsbukt near the Rystrøm 633 m, Vika on Vega 873 m, Bjørn on Dønna 920 m, Skagstad on Engeløy in Steigen 823 m and North Fugløy in Gildeskål 953 m. Most of these localities lie outside the inshore channel, the ordinary fairway. From these figures may be concluded that the thickness of the last ice sheet on the continental shelf off the coast of Helgeland and Salta was between 800 and 900 m. If the present depth of the part of the shelf then covered by ice is supposed to be on an average 250 m the ice sheet should have risen to between 550 and 650 m above the present sea level. North of Lofoten the thickness was less, between the islands in Troms fylke only between 500 and 600 m, 250 to 300 m above the present sea level.

From the main territory of accumulation to the east of the frontier the ice was pressed in westerly and northwesterly direction over Northern Norway where it filled up the valleys and flowed over the mountain wilds. There the ice had its greatest velocity and made its most important eroding work, but off the coast the partially separated ice streams merged together to a more or less continuous ice plateau or ice barrier of decreasing thickness and motion westwards. The continental shelf was in that way a secondary area of accumulation for ice and loose material where the ice must be a dead mass from the moment when the ice flow from the east no longer could overcome the friction within the mountainous inland.

A calculation similar to that above concerning the islands can also be carried out for localities on the mainland on fjords and in valleys. The figures found are for some localities the following: At Eidstrand near the north point of the Lyngen peninsula 653 m, at Skarmok 763 m, at Målsnes in Malangen 760 m, at Heldal in the Folla district 960 m, at the mouth of Bindalsfjord and at Eidet on the south side of Velfjord 1033 m, at the head of Leirfjord in Folla 1103 m, at Søfting on the north side of the Vefsenfjord 1117 m, at Børjeør at the head of one of the inner branches of Velfjord 1123 m, at the head of Elsfjord in the Rana district 1187 m, at Setså on the east side of the inner part of Skjerstadfjord 1190 m and at Bergulnes in the Saltdal 1323 m. All these localities are situated within the part of the land where the erosion took place and where the real thickness of the ice was very much varying on account of the unevenness of the ground below the ice. The figures found, therefore, do not have the same value as figures from localities on the continental shelf but they may still give a faint idea of the elevation of the ice surface within the mountainous districts. An attempt at finding a probable value of the depression at the centre and the thickness of the ice there has given as result a depression of about 700 m and a thickness of the ice of between 2300 and 2400 m.

The calculations dealt with above do not as a matter of course pretend to be something more than a rough approximation based on suppositions more or less questionable. It is supposed that the n-line is accurately fixed and is the oldest late glacial shore line, and can be lengthened outside districts where measurements had been carried on. It is further supposed that the eustatic stand of the sea level was about 100 m below the present level when the m-line was engraved, that the speciphic gravity of glacier ice is 0,9 and of the inner masses equal to 3, every one of them being more or less disputable. It is therefore of rather great interest that the calculated figures, despite so many suppositions, are, however, of the same order according to size as the figures found either by field work or by looking over the maps. I should therefore be inclined to think that the thickness of the last ice sheet has hitherto been underrated especially from the Lofoten islands southwards. A concave bending of the ice front off the said part of the coast as seen on some maps showing the extension of the ice, for instance the map by Granlund in Sveriges geologi, p. 139, cannot be correct. A straight course or a convex bulging out of the ice front is more likely as it is in accordance with the direction of the isobases along this part of the coast. This part of the ice front lay, moreover, nearer to the centre of the glaciation than any other part of the front. The extension of the ice sheet to the south and southeast in Germany and Russia may also give a hint of the dimensions which ought to be taken into consideration. The ice masses moving westwards had, it is true, a mountain ridge to pass, but this hindrance was compensated for by a shorter distance from the ice divide to the outer border.

A calculation similar to that carried out above concerning the supposed uppermost shore line and the lowest stand of the sea level cannot as a matter of course be carried out for younger levels and give results of the same value, for it is but a minute probability for a balance between load and depression after the melting period had set in with full strength. In warm periods the melting would be so quick that the rise of the land surface could not keep up to it. The rise would be retarded as seen in the present time, for the land is even now rising though the ice sheet has melted away long time ago.

But during the melting period, however, once the ice front was stationary for some length of time at the Tromsø-Lyngen stage. The ice front rose then rather steeply from the level of the sea to above 200 m, and at the same time the level of the sea seems to have been in relative rest. By counting alternate layers of coarse and fine loose material on the Breivikeid about 5 km outside the former ice front about 600 double layers have been found, and if supposed that each double layer represents the deposition of loose material in a year, then the melting was reduced for so long a time that balance between load and depression once more may have taken place. It is also likely that the thickness of the ice sheet had been increasing which the strong local glaciation on the islands outside the ice front seems to indicate. During the stationary stage the shore lines g_2 and g_1 were engraved but when the next line, the g-line, was engraved a new and strong melting period had started. In the diagram the n-line at Bergulnes lies 297 mm above the zero line and the g-line 186 mm above the same line. To the former figure corresponds an eustatic stand of -100 m and to the latter -84,8 m. The depth of the depression was therefore in the time of the n-line 397 m and in the time of the g-line 270,8 m or 68,2 %. In case of equilibrium between the thickness of the ice and the depth of the depression in the latter time the thickness of the ice should then have been 68,2 % of 1323 equal to 902 m. As formerly mentioned a melt water river once made its way across the present divide from the Saltdal to the Bjellådal at a level of 844 m. This river, no doubt, only existed in a melting period and most likely at the beginning of such a period as was the time of the g-line. The surface of the Saltdal glacier was then situated at about 900 m above the present sea level, and it fits quite well after all. It must here be put in mind that the oldest ice dammed lake in the Bjellådal lay 765 m above the present sea level. This fact shows that also in the Dunderlandsdal a valley glacier must have existed at that time of similar dimensions as the glacier in the Saltdal.

In the Signaldal 25 km from the head of the Lyngenfjord is the great canyon, fig. 11, cut in the eastern mountain side. The bottom of the canyon lies about 550 m a. s. l. In the diagram the n-line there lies 209,5 mm and the g-line 126,5 mm above the zero line. The depression was therefore in the n-time 309,5 m and in the time of the g-line 211 m or 68,2 %. The corresponding thickness of the ice sheet was for the n-time 1032 m and for the g-time 703,8 m. The upper wall of the canyon is about 50 m high and therefore the cutting of the canyon in the solid rock must have started while the border of the valley glacier lay above 600 m above the present sea level, and the calculation is in accordance with this fact. The canyon has, no doubt, been cut by a rapid river abounding with water which proves that there must have been an intense melting on the surface of the ice. The cutting of the canyon must therefore have taken place in the time of the ice dammed lakes in the Bjellådal.

In the northern part of the Lønsdal and in Dypenådal heavy masses of sand and gravel have been deposited in an ice dammed lake between the mountain side to the east and glacier ice in the Lønsdal and the Saltdal to the south and north. The deposition has taken place in three steps 713, 670 and 640 m above the present sea level, showing three different levels of the ice dammed lake (19). This lake is of a later date than the ice dammed lakes in the Bjellådal. Of special interest is that the existence of this lake clearly proves that the ice sheet now was broken at the frontier or was about to be broken. It is likely that so was the case all along the frontier northwards to the Tysfjord district, while farther to the north the valley glaciers still were supplied from the east through defiles on the frontier.

After partition of the ice cover along the frontier had taken place our valley glaciers would be "dead" if not sufficiently fed from locally glaciated areas, but such a supply may not often have been of any importance.

Norsk resymé.

Innledning.

I de senere år har flere forfattere behandlet Nord-Norges kvartærgeologi mere eller mindre inngående, og blandt disse især Tanner, Nordhagen og Undås. Da nærværende forfatter i årenes løp har samlet materiale av forskjellig slag vedkommende dette emne, har han funnet det riktig å fremlegge den del av materialet som nogenlunde er gjennemarbeidet og gi en foreløpig redegjørelse for de resultater han er kommet til.

I. Den store istid.

Det er hittil i Nord-Norge bare påvist spor efter to nedisninger, en første større og en siste mindre nedisning. Den store innlandsis var så mektig at den dekket fastlandet, så det neppe fantes en eneste nunatak der, men det er sannsynlig at der var nunatakker i den vestlige del av Langøy i Vesterålen og i Lofoten. Det er denne store innlandsis som har utført det vesentlige erosjonsarbeide både inne i landet og på øyene, planert fjellviddene, rundet de fleste topper og rygger og gravet ut de dype traug inne i fjordene. Den har lagt igjen store flyttblokker i store høider ikke bare inne i landet, men også på øyene langt ute. Således finnes det flyttblokker på Kvaløy til over 600 m, på Hadseløy til 450 m og på Værøy til 400 m o. h. Også øyene innen Røstgruppen synes å ha vært oversvømmet av isen under denne nedisning. Det er sannsynlig at den utenfor hele kysten av Nordland gikk helt ut til eggen og der stod med loddrett vegg mot dyphavet vestenfor. Vest for Senja er hele bunnen utover til eggen dekket av store kuppelstein, overveiende vel rundede, av eruptive bergarter.

II. Den siste istid.

Langs fjordene og dalene er det en mere eller mindre skarp skillelinje mellem en nedre del av fjellsiden som er konkav og en øvre del som er konveks og opover går over i de flate fjellvidder. Langs den nevnte skillelinje finner man nu ofte moreneterrasser, steinrekker, tørre elvefar m. m. som må antas å skrive sig fra stasjonære stadier av en innlandsis under avsmelting. Flere sådanne linjer over hverandre viser at det med mellemrum må ha vært flere sådanne stasjonære stadier under avsmeltingen.

En del sådanne morenelinjer og andre randfenomener gjennemgåes. Av større interesse vilde det være om man kunde finne ut den maksimale mektighet av denne innlandsis, og på grunnlag av dels arbeide i marken og dels gjennemgåelse av de topografiske kart blir det sannsynliggjort at den siste innlandsis har hatt en mellem 400 og 500 m mindre mektighet enn den store innlandsis. Følgen av denne mindre mektighet var at der i det indre av landet nu stakk op en hel del høie topper som nunatakker. De indre fjellvidder var nok også da dekket av is, men isdekket var ikke så tykt og hastigheten ikke så stor at der blev utført noget betydelig erosjonsarbeide. Dertil kom at den siste innlandsis vesentlig måtte arbeide i friskt berg. Alle daler og fjorder var fulle av is, og det var disse breer som gav dal- og fjordsider den siste utformning. Utenfor kystlinjen fløt fjordbreene sammen til et isplatå som dekket en stor del av den kontinentale platform. Utenfor Nordlandskysten hadde dette isplatå sin største mektighet, over 800 m med avtakende mektighet vestover. På pl. III er den antakne ytre rand avsatt som en sammenhengende linje. Sannsynligvis endte den med en kalvingsfront mot havet i vest.

Nu er det et spørsmål om ikke den siste nedisning bare var et avsmeltingsstadium av den store istid. Mot dette taler et funn av skjell presset inn mellem steinheller i et steinbrudd i Tromsø by, likeså et avtrykk av et olderblad, funnet på samme sted. Dette funn kan vanskelig forklares på annen måte enn som interglacialt. Men det beste bevis for en interglacial tid mellem de nevnte innlandsiser er dog de fjellplanter som Nordhagen nevner både fra det nordlige og det sydlige Norge, som han kaller interglaciale overvintrere, og som må være innvandret i en interglacial tid (14 og 15).

III. De senglaciale strandlinjer.

I tabellen over målematerialet er foreløpig bare egne målinger brukt, fordi disse for det meste er nivellementer og lokalitetenes beliggenhet og verdi var kjent fra arbeidet i marken. Av de 320 lokaliteter som er tatt med er 312 fra Nord-Norge og 8 fra Novaja Semlja. I den grafiske fremstilling er abscissene proporsjonale med stigingshastigheten og ordinatene er i en bestemt lengdemålestokk. Mitt diagram, pl. II, er både horisontalt og vertikalt omtrent så stort som Tanners diagrammer fra 1930, altså vertikalt 1 : 1000, 1 mm pr. m, horisontalt 1 : 200 000, 1 mm pr. 200 m. Likesom Tanner har jeg brukt Tapes-linjen (b-linjen) som styrelinje, og for å sikre den best mulige bestemmelse av denne linje, har jeg med anvendelse av hele mitt målemateriale utarbeidet et isobasekart for dette nivå, pl. I.

De øverste linjer p til n_1, i diagrammet, pl. II, er bygget på lite og usikkert materiale, og da de ikke er påvist som marine grenser på de ytterste øyer kan de ikke være marine strandlinjer. Den øverste sikre marine strandlinje er n, den nest øverste m. For ikke å bringe inn nye vanskeligheter med betegnelsen har jeg stort sett brukt de samme bokstaver som Tanner på linjer som var identisk med hans. Tvilsomme linjer eller linjer som ikke finnes igjen i Tanners diagrammer har jeg derfor bare betegnet med et punkt.

Ved å følge strandlinjene fra de ytterste kyststrøk østover viser det seg at stadig yngre strandlinjer markerer den øverste marine grense. På den måte gir strandlinjene beskjed om isfrontens tilbakerykking under avsmeltingen, og for en del mere eller mindre stasjonære stadier kan derfor isfrontens stilling så nogenlunde fikseres. Sikrest kan dette gjøres for Tromsø—Lyngen stadiet, da isfronten i Troms fylke lå i ro i flere hundre år og svære morener blev avsatt. I Nordland fylke kan imidlertid heller ikke dette stadium med nøiaktighet bestemmes, da isfronten der enda lå utenfor kystlinjen og neppe var helt stasjonær. Yngre stasjonære stadier som mere eller mindre nøiaktig kan fikseres er i pl. III merket med M, M' og M''.

Som et tillegg til dette avsnitt er tatt med en sammenstilling av Nord-Norge og Oslofeltet på grunnlag av strandlinjediagrammet. Denne sammenstilling gjør ikke fordring på å være av nogen stor nøiaktighet og er derfor ikke underkastet nærmere diskusjon.

IV. Ligninger for linjene i et strandlinjediagram. Den eustatiske stand av havnivået.

Linjene i strandlinjediagrammet kan uttrykkes ved ligninger av formen $y = kx + b$. Kalles den vertikale linje som begrenser diagrammet til høire y'' og en annen vertikal linje 500 mm til venstre for denne y', så er

$$k = \frac{y'' - y'}{500} \text{ og } b = y'$$

hvorfor ligningen blir

$$y = \frac{y'' - y'}{500} x + y'$$

Da alle linjer i diagrammet skjærer disse to vertikale linjer, kan y'' og y' for hver linje tas ut av diagrammet med en nøiaktighet som avhenger av diagrammets vertikale målestokk. For n-linjen er $y'' = 305$ og $y' = 122{,}7$ mm. Derfor blir for linjen

$$n: \; y = \frac{305 - 122{,}7}{500} x + 122{,}7 = \frac{182.3}{500} x + 122{,}7 = 0{,}3646\, x + 122{,}7$$

På samme måte finnes ligningen for næste linje

$$m: \; y = 0{,}3600\, x + 119{,}9.$$

Skjæringspunktet mellem disse to linjer er ca. (- 610, - 100). På grunn av diagrammets egenskaper er ordinaten bare avhengig av den vertikale målestokk. Om man således lar avstanden mellem de to vertikale linler y'' og y' være en vilkårlig lengde l i stedet for 500 mm, vil det ikke ha nogen innflytelse på ordinatene for skjæringspunktene mellem linjer, da l faller bort under beregningen av y. Linjen m blev efter dette innskåret under en havstand ca. 100 m under den nuværende. Finnes på samme måte skjæringen mellem n og de nærmest følgende linjer k_2 og k får man på det nærmeste de samme verdier, og det skulde tyde på en nokså liten bevegelse av havnivået under den første del av landets stiging. Det er forutsatt at skjæringspunktet mellem n og m lå på den vestre grenselinje for depresjonen, at landets stiging stort sett foregikk som en dreiing om dette punkt og at havets eustatiske bevegelse foregikk i parallelstilling til det nuværende nivå. Man kan nu tenke sig diagrammet dreibart om punktet (n, m) og diagrammets 0-linje fiksert ved hjelp av en spent tråd. Dreier man nu diagrammet om (n, m) så de forskjellige linjer efter tur kommer i parallelstilling til tråden, kan man direkte ved måling finne ut stillingen av det havnivå i hvilket hver enkelt linje blev inngravet. Større nøiaktighet vil man opnå ved å overføre ligningene for linjene i diagrammet til normalformen

$$\frac{y - kx - y'}{\sqrt{1 + k^2}} = 0$$

og så sette inn koordinatene for skjæringspunktet mellem n og m i ligningen i stedet for x og y. Man finner ved denne regning de forskjellige linjers avstand fra dette punkt og forutsettes det at det lå i ro i forhold til 0-linjen, kan deres avstand fra denne lett beregnes. Ved en sådan regning er kurven, pl. V, funnet.

V. Forholdet mellem størrelsen av en depressjon og tykkelsen av den iskappe som fremkalte den.

Det må antas at der i de områder som engang var belastet med is var størrelsen av den depressjon som iskappene forårsaket avhengig av vekten av den ismasse som fremkalte den. Da de hevede strandlinjer innen sådanne områder blev innskåret under en annen og i alminnelighet lavere havstand enn nu, må den virkelige størrelse av en depressjon bli å finne ved å legge sammen høiden av den øverste strandlinje og avstanden av det tilsvarende havnivå til det nuværende. Ifølge det foregående var linjen n i diagrammet den eldste senglaciale strandlinje, og til samme tid skulde ifølge kurven, pl. V, for den eustatiske stand havnivået ha ligget omtrent 100 m under det nuværende havnivå. Var nu disse antakelser riktige, skulde man kunne beregne tykkelsen av den ismasse som fremkalte depressjonen tilnærmet ved hjelp av følgende likevektsligning:

$$0{,}9\,H = 3\,(h + q),\ H = \frac{10}{3}(h + q)$$

hvor H er istykkelsen, h er strandlinjehøiden på samme sted, 0,9 isens specifike vekt, 3 den specifike vekt av de indre masser som var blitt trykket til side under depressjonen og q havets stand under nuværende nivå. Ved å sette q = 100 og så regne ut den istykkelse som skulde svare til en depressjon til linjen n er funnet henimot 900 m utenfor kysten av Helgeland og noget mindre lengere nord. Depressjonen inne ved grensen skulde svare til en vekt av ca. 1400 m iskappe. De verdier som er funnet er av samme størrelse som de man kommer til ved direkte undersøkelse og er derfor rimelige.

Foruten denne beregning av isens maksimale tykkelse er der også foretatt en beregning for den tid da isranden antokes å ligge ved Tromsø—Lyngen morenene, da det var en mulighet for at isen dengang var så lenge stasjonær at der atter blev likevekt mellem depressjon og belastning. Regningen gir sannsynlige resultater.

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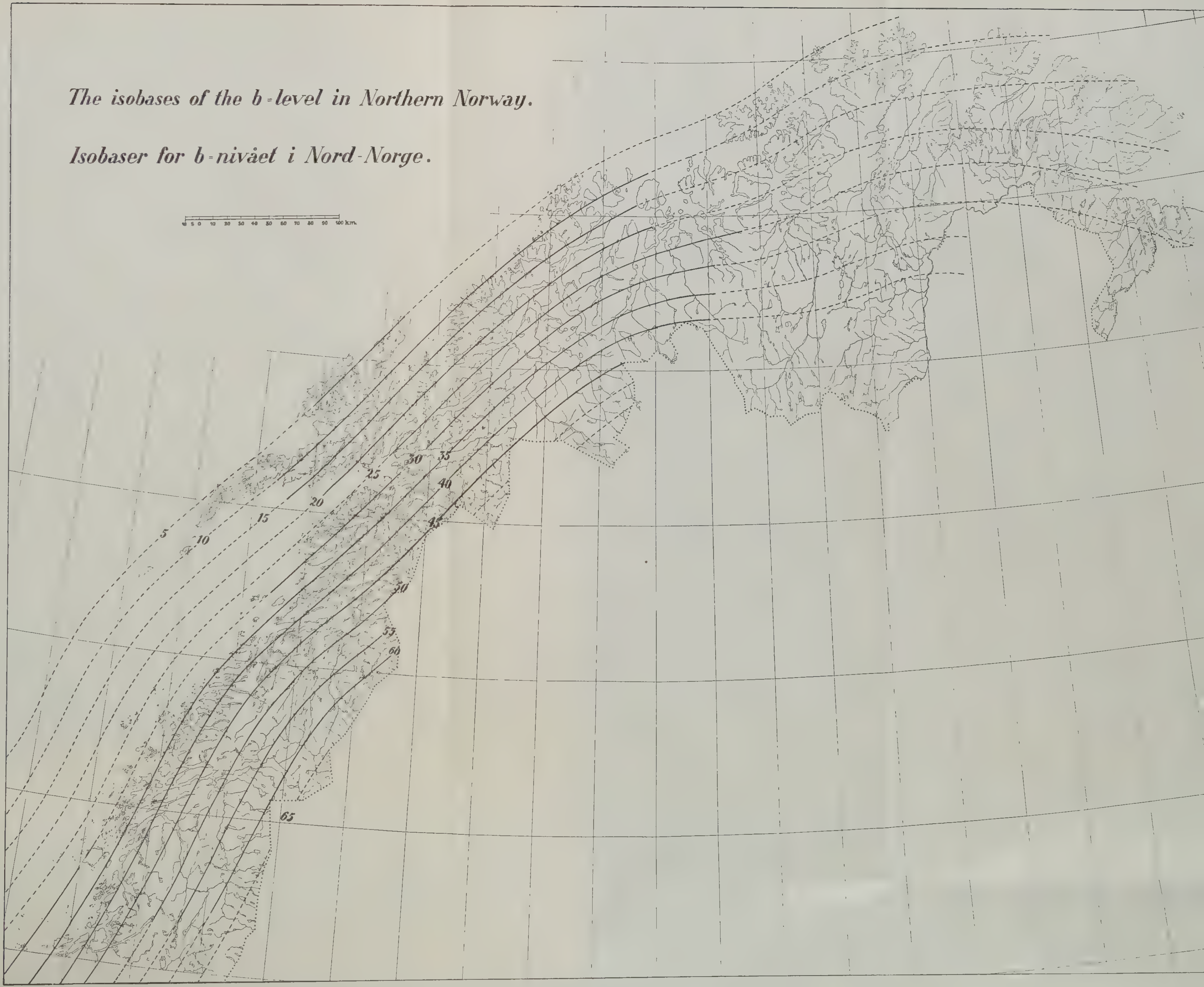
EXPLANATION OF THE PLATES

Pl. I. The isobases of the b-level in Northern Norway.
Pl. II. Diagram of the shore lines » » »
Pl. III. Some supposed stands of the ice front during the melting of the last inland ice.
Pl. IV. Diagram of some levels in the Oslo-Romerike district.
Pl. V. A curve showing the eustatic stand of the sea level while the shore lines were engraved during the melting period of the last inland ice.

Printed April 30th, 1940.



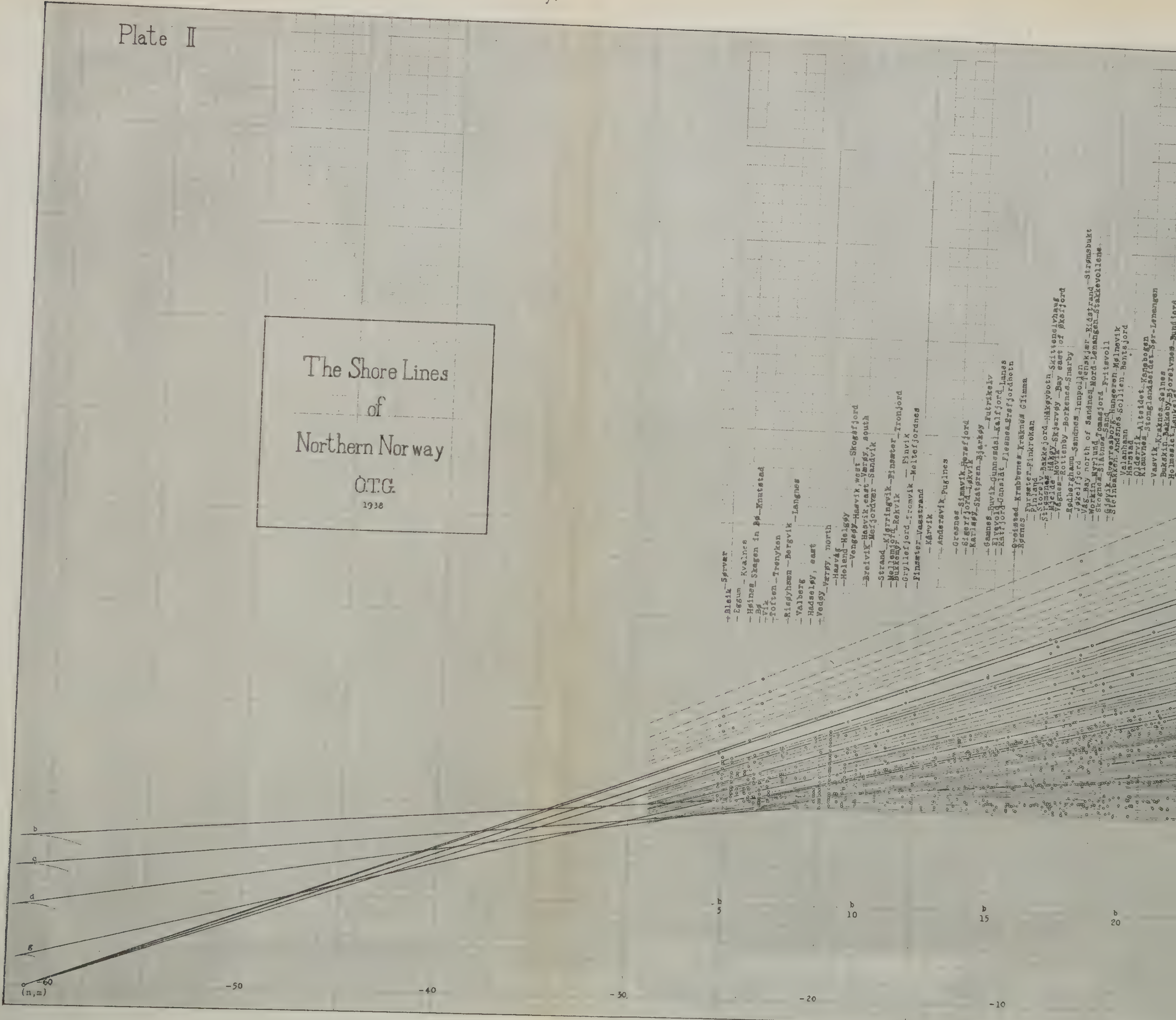
The isobases of the b-level in Northern Norway.

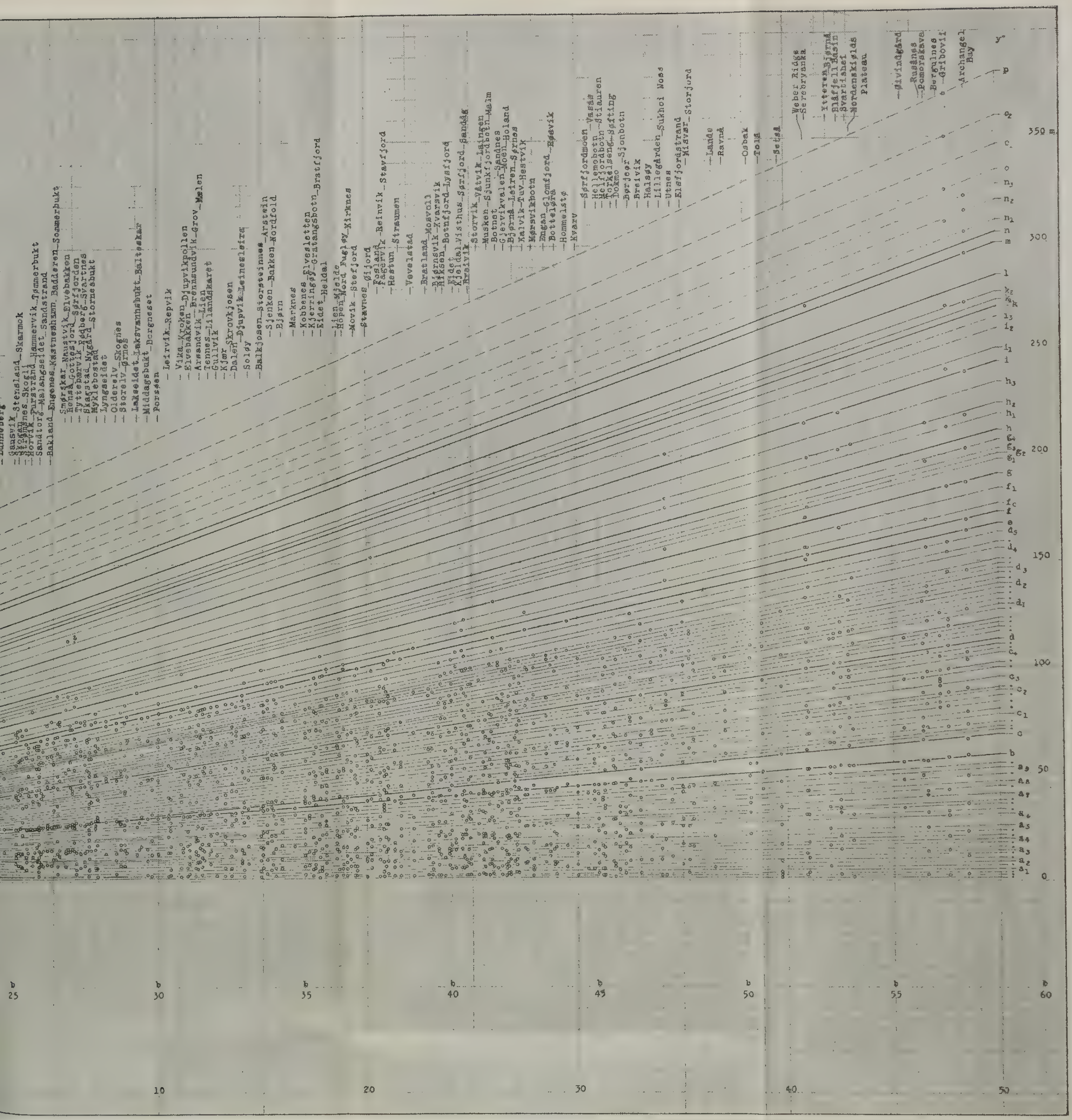
Isobaser for b-nivået i Nord-Norge.

Plate II

The Shore Lines of Northern Norway

O.T.G.
1938




Sausvik_Stensland_Skarmok
Korgan
Strømsnes_Skogli
Horvik_Purstrand_Hammervik_Tømmerbukt
Sandtorg_Malangseidet_Sandstrand
Bakland_Engenes_Kastneshamn_Badderen_Sommerbukt
Snørskar_Naustvik_Elvebakken
Rensa_Gottesjord_Sørfjorden
Tyttebærvik_Rødberg_Svartnes
Skagstad_Nygård
Myklebostad_Stornesbukt
Lyngseidet
Olderelv_Skognes
Storelv_Ørnes
Lakseidet_Laksvannsbukt_Baltesskar
Middagsbukt_Bergneset
Porsøen
Leirvik_Repvik
Vika_Kroken_Djupvikpollen
Elvebakken_Brennsundvik_Grov_Maelen
Arsandvik_Lien
Tennes_Lillandskaret
Gullvik
Kjær
Dalen_Skrovkjosen
Djupvik_Leinesleira
Soløy
Balkjosen_Storsteinnes_Arstein
Sjenken_Bakken_Nordfold
Bjørn
Marknes
Kobbenes_Elvesletten
Kjerringøy_Gratangsbotn_Bratfjord
Eidet_Heldal
Lien_Mjelde
Hopen_Nord Fugløy_Kirknes
Movik_Steffjord
Stavnes_Øijord
Fosland
Fagervik_Reinvik_Stavfjord
Hestun_Straumen
Vevelstad
Bratland_Mosvoll
Bjørnsvik_Kvarsvik
Riksen_Botnfjord_Lysfjord
Eidet
Kjeldal_Visthus_Sørfjord_Sandåg
Breivik
Storvik_Våtvik_Laingen
Musken_Sjunkfjordbotn_Malm
Botnet_Sandnes
Gjervikvalen_Moen_Holand
Bjørnå_Leiren_Sørnes
Kalvik_Tuv_Hestvik
Mørsvikbotn
Engan_Glomfjord_Røsvik
Bottelsøra
Hommelstø
Kvarv
Sørfjordmoen_Vassa
Hellemobotn_Stiauren
Helfjordbotn
Torkelseng_Søfting
Dokmo
Børjeør_Sjonbotn
Breivik
Halsøy
Lilleqården_Sukhoi Noss
Utnes
Elsfjordstrand
Misvær_Storjord
Lande
Ravnå
Osbak
Tolå
Setså
Weber Ridge
Serebryanka
Ytteren_Bjørnå
Blåfjell Basin
Svartisbel
Nordenskiøld Plateau
Øivindgård
Rusånes
Pomorskava
Bergulnes
Gribovil
Archangel Buy
y''
p
o2
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o
n3
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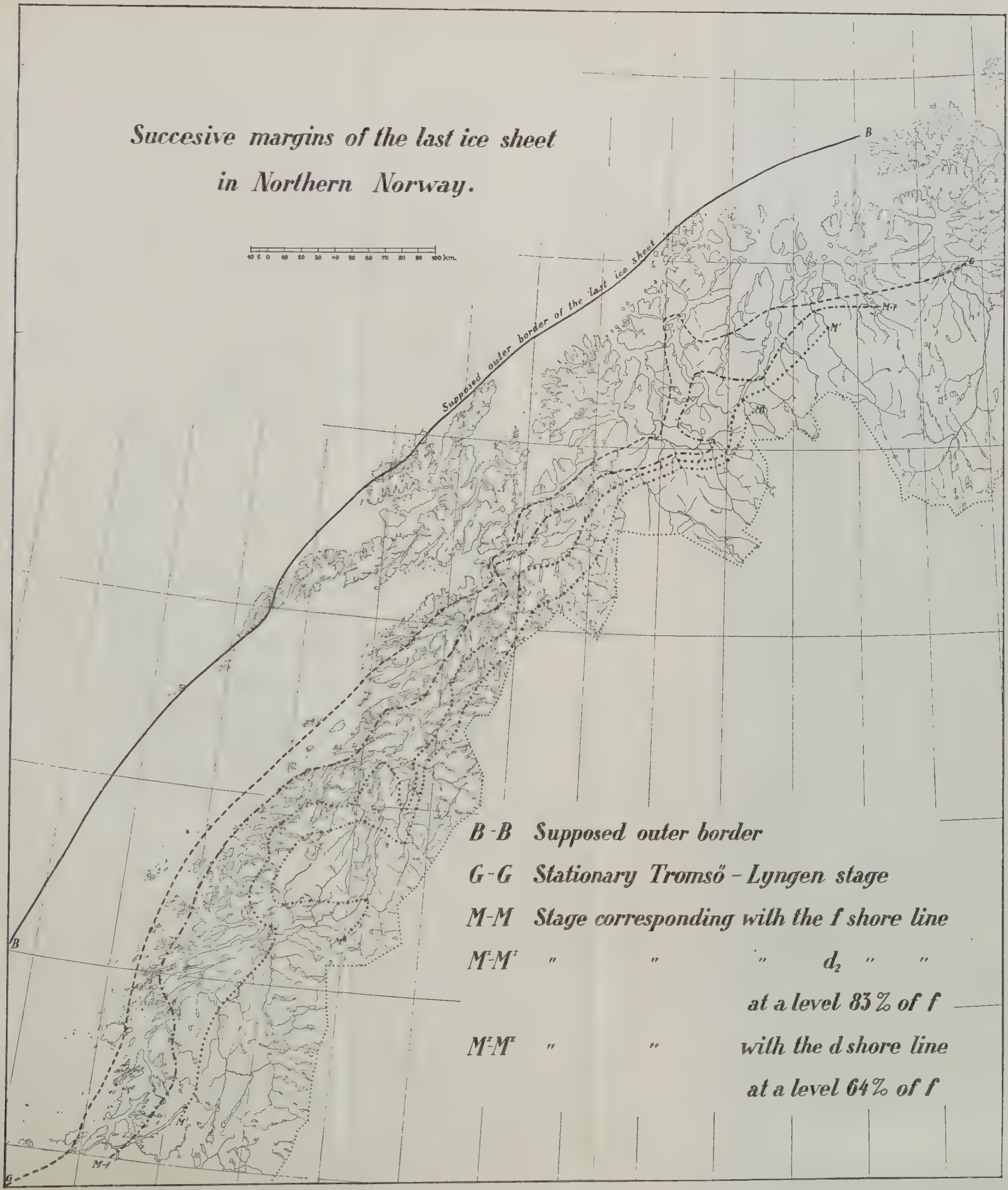
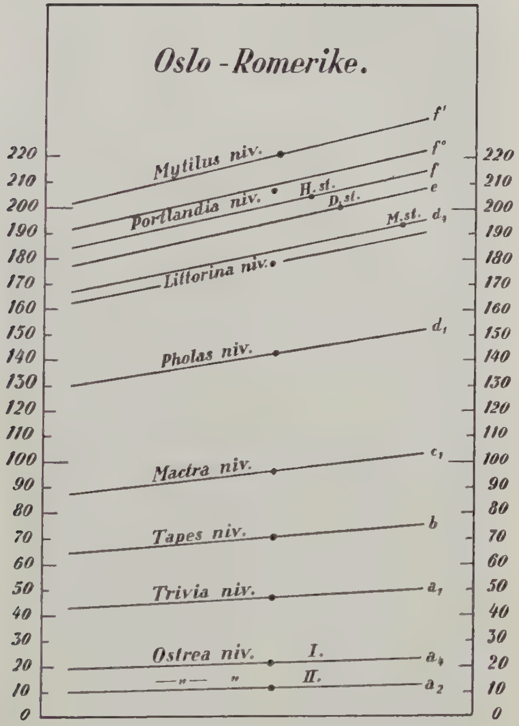

Succesive margins of the last ice sheet in Northern Norway.
10 5 0 10 20 30 40 50 60 70 80 90 100 km.
B
B
G
G
M-f
M-f
M^1
M^1
Supposed outer border of the last ice sheet
B-B Supposed outer border
G-G Stationary Tromsö – Lyngen stage
M-M Stage corresponding with the f shore line
M^1-M^1 " " " d_2 " " at a level 83% of f
M^2-M^2 " " with the d shore line at a level 64% of f


Oslo-Romerike.
Mytilus niv.
Portlandia niv.
H. st.
D. st.
M. st.
Littorina niv.
Pholas niv.
Mactra niv.
Tapes niv.
Trivia niv.
Ostrea niv.
I.
— " — "
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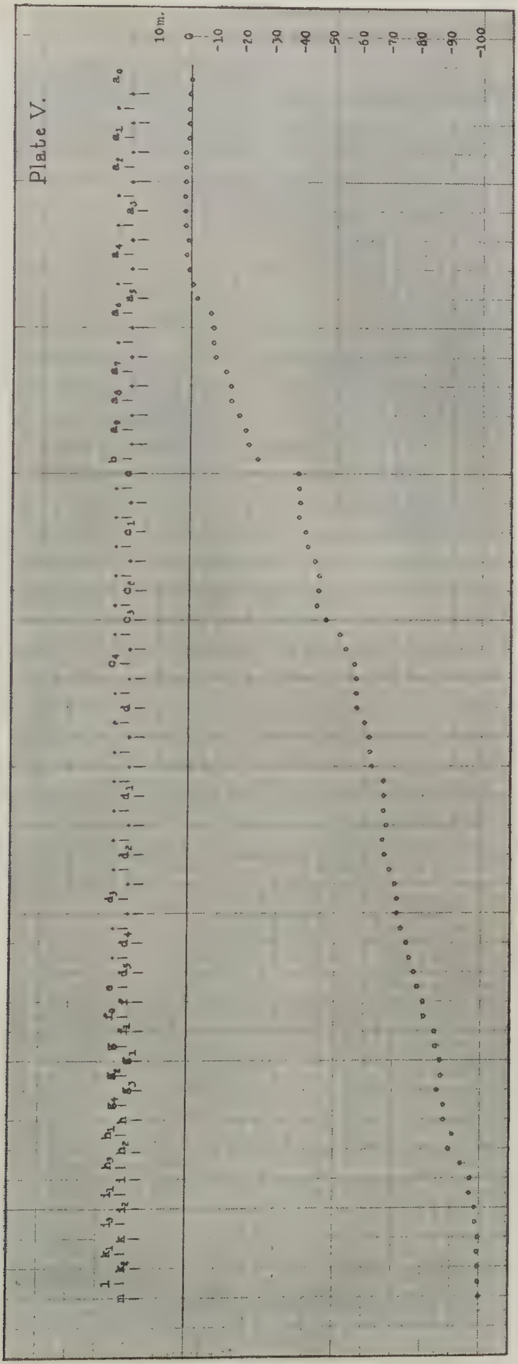
Plate V.
10 m.
0
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-80
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-100
a0
a1
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a9
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c1
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c3
c4
d
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d5
e
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g
h
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i1
i2
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k1
k
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l
m

M. s. rec. Aug. 3, 1939.

GEOLOGICAL AND PETROGRAPHICAL INVESTIGATIONS IN THE ARENDAL DISTRICT

BY

JENS BUGGE

WITH 15 FIGS. IN THE TEXT AND 4 PLATES

Abstract. The rocks of the Arendal district in Sørlandet, Norway, are all of pre-Cambrian age and belong to the Kongsberg—Bamble formation. This paper chiefly deals with the south-western part, which is shown in the geologocal map, fig. 13 and marked by the hatched triangle on fig. 1.

Evidence is cited to show that the oldest rocks are of supra-crustal origin, including quartzites, limestones, effusives, para-gneisses etc. The banded gneisses, so common in pre-Cambrian formations, are also supposed to belong here.

During an orogenic period the rocks were strongly folded and invaded by igneous and migmatic rocks, ranging in composition from hyperites, norites and hypersthene diorites to charnockites and granites. During this time the rocks of the old complex were to a high degree changed to migmatites and granites.

The skarn-iron ores of Arendal all belong to the old supra-crustal system and are of metamorphic origin.

They have been mined for more than 250 years and were in the 18th century among the most important in Norway.

Some of the mines are about 250 m deep, but the total production is only about 2 3/4 mill. tons. After 1870 there has been work only at Klodeborg and Bråstad, which were abandoned in 1920. Tectonics and mineral parageneses of the deposits are briefly discussed.

CONTENTS

Pag.
Preface 72
Previous Work 72
I. Geological Description 73
1. Quartzites 73
2. Conglomerates 75
3. Banded Gneisses 75
4. Limestones 78
5. Hyperites 79
6. Arendalites 81
The Basic Division 82
The Intermediate Division . 83
The Acid Division 86
Tectonics 88
7. Quartz — Biotite Diorite ... 88
8. Granites 89
The Oldest Red Granites .. 89
The Granite Pegmatites ... 89
The Grimstad Granite 91
9. The Regional Migmatites .. 91
10. The Skarn Zones 92
II. The Main Skarn Zone 93
1. Mineralogy 93
2. Petrology and Genesis 98
3. Geological Discription 101
Summary 108

Preface.

The investigations in the Arendal district were carried out during the years 1937 and 1938 for the Geological Survey of Norway on the initiative of Director Carl Bugge.

The collection of the Survey, geological maps, rock specimens, slides etc.,chiefly collected by the Director, were kindly put at my disposal. I would thank him for his valuable advice and the many helpful discussions of the problems, which have been of the greatest importance for my work.

My sincere thanks are also due to Professor V. M. Goldschmidt for his kind help and advice and for the great interest he always has shown in my investigations.

The laboratory research was carried out at the Mineralogical Institute of the Oslo University and the Director, Professor Barth, kindly placed all the equipment of his institute at my disposal. For his valuable criticism of the manuscript and all his assistance both in my present work, and previously, I am greatly indebted.

The microphotos were taken by Mr. J. Stadheim and the maps drawn by miss D. Engelsrud.

Mineralogisk Institutt, Oslo.
August 4, 1939.

Previous Work.

The first detailed investigations of the ore district were carried out by Th. Kjerulf and T. Dahll 1861 (Fig. 15).

J. H. L. Vogt has in several papers discussed the origin of the ores. He regarded them as contact-metamorphic, and also mentioned the similarity to many skarn-ores in Middle-Sweden.

Quite recently, Thorolf Vogt (1937) has tried to compare the Bamble formation with the Svionian in Sweden. He bases his contentions on the relationship between the ore-deposits in the two districts, and he also emphasizes that the rocks of the Bamble formation strike in the same direction (NE—SW) as those of the Svionian.

Interesting facts about the archean of Southern Norway are also published by W. C. Brøgger, O. Holtedahl, T. F. W. Barth, I. Oftedal et alii.

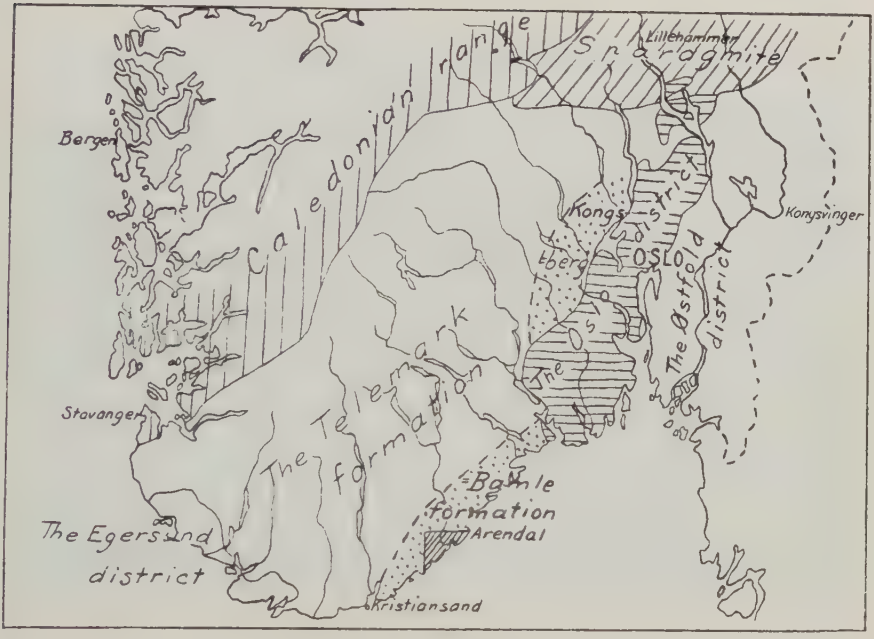

Fig. 1.

In recent years the Bamble formation has been systematically mapped by the Geological Survey of Norway Olaf Andersen (1931), Arne Bugge (1928, 1936), Carl Bugge (1917), and we can now partly follow and reconstruct the geological history.

I. Geological Description.

1. Quartzites.

Quartzites have been described from several parts of Sørlandet, but their origin is still a matter of discussion among Norwegian geologists.

They often occur in connection with hyperites (or amphibolites) and seem also to pass by gradation into true granites. Some geologists (e. q. y. Arne Bugge) have therefore entertained the idea of a possible magmatic mode of origin of the quartzites. Further investigations have shown, however, that the quartzites have a wide distribution and belong to a formation which I can only explain as sedimentary. The rocks are best preserved in the north-western parts of the Arendal district and wedge out towards NE and SW. Here they often are migmatized and granitized to a high degree, and we may pass from true quartzites to true granites in the strike directions.

The south-eastern border of the quartzite formation extends from Rorevatn—Løddesøl—Rossedalen towards NE. Towards SE the quartzites form a broad transitional zone which merges into the next zone which I have named *the Regional-migmatite zone* (see page 21).

The quartzites are always wholly recrystallized and I have never found any traces of clastic structures. Transparent varieties are common. The strike varies from N—S to NE—SW and the dip is usually vertical.

They always contain small well-oriented biotite scales, giving the rocks a gneissic aspect. Grains of feldspars are common. It usually is an acid saussuritized plagioclase where zoisite, sericite and calcite is observed in the ground mass. Potash feldspars are not so common and seem to be limited to the borders of the quartzite areas. While the plagioclases may be regarded as clastic relics, the microcline mostly is of metasomatic origin.

Minor constituents of pneumatolytic origin are tourmaline (shorlite), rutile and zircone. Of these minerals tourmaline is the most important and is sometimes the only mineral besides quartz. It is interesting that tourmaline usually occurs in connection with the quartzites and very seldom is found in other rocks. The pure quartzites seem to be more resistive to granitisation than the impure, and while these and the other rocks may be migmatized and granitized to a high degree, the pure quartzites occur as relics only granitized in the peripheral parts.

Sillimanite occurs, but seems to be more rare than in other parts of the Bamble formation.[1] It is described from several parts of the Arendal district by Arne Bugge and other geologists.

Quartz is generally strongly pigmented, due to small inclusions, often occurring in parallel lines (the Boehm striation), partly representing liquid inclusions. Investigations of the petrofabric have not yet been carried out, but are of the greatest importance (see A. Hietanen 1938).

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[1] Instead of the Kongsberg-Bamble formation I commonly use the shorter name the Bamble formation.

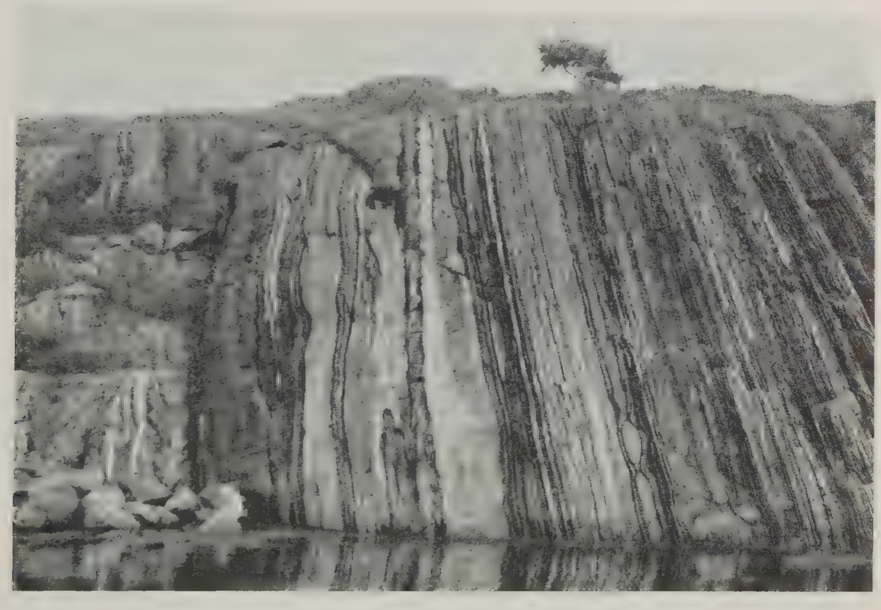

Fig. 2. Banded gneiss. Morvigen, Landvig.

2. Conglomerates.

Rocks, resembling conglomerates, from several parts of the Bamble formation, have been described under the name pseudo-conglomerates. In the Arendal district, at Krogen, Rorevann, we find similar rocks. Possibly, they represent highly metamorphic quartz-conglomerates. The pebbles, mostly consisting of quartz, are highly deformed and stretched. Since similar rocks are found elsewhere in the Bamble formation, they may help us to find discordances in the old supra-crustal systems.

3. Banded Gneisses.

In the Arendal district we find banded gneisses in the belt of rocks bordering the coast. They are built up of alternating dark and light "bands" of varying thickness, from a few cm up to several meters. The "bands" consist of amphibolites, biotite quartzites, dioritic and granitic gneisses. Seen from a distance, both the strike and the dip seem to be very constant. Usually the strike is about NE—SW and the dip 50—80° SE (Fig. 2), but detailed investigations show that we have a strongly folded formation of isoclinal folds with folding planes dipping SE (Pl. I, Fig. 1).

Both a horizontal and a vertical plane cut the folds obliquely and, knowing the projection on both these planes, we are able to construct the folds. Due to the marked difference in colour of the bands, it is generally easy to distinguish the different bands or layers even when they are strongly deformed. The effect of different orientation of the folding axes is shown in Fig. 3.

The amphibolites contain as essential minerals green amphibole and plagioclase with 40—60 % An.

The amphibole is usually coarsely crystallized and gives the rock a gneissic structure. Often it is poicilitic, containing rounded grains of plagioclase. Relics of both orthorhombic and monoclinic pyroxenes bestow on the rock a similarity to the hornblende norites belonging to the charnockite series (arendalite).

The original structures are always obliterated, but investigations of the tectonics of the banded gneisses indicate that the layers originally were lying nearly horizontally; the amphibolites are therefore best explained as basic effusives.

The acid rocks, exhibiting a very varying composition, may partly be explained as effusives (leptites), partly as sediments, and partly as metasomatic rocks. Occasionally we find small areas of biotite quartzites, resembling the north-western quartzites, and certainly representing relics not obliterated during the granitisation. Transitional zones between all the types of rocks are characteristically present, they must have been formed during the metasomatism, thus representing a stage in the homogenisation of the rock complex.

In some areas, the banded gneisses are seriously deformed. We find agmatites, nebulites, dictyonites, ptygmatites etc. (Pl. I, Fig. 2). The amphibolite bands are often broken and the fragments show every transition from amphibolites to diffuse, partly assimilated rock types. The minerals of the original amphibolite have become unstable, and have been changed to minerals in equilibrium with those of the surrounding rocks, amphibole to biotite etc.

It is impossible to understand the formation of the agmatites if the acid rocks, especially the quartzites, under certain thermodynamical conditions did not behave like a plastic mass that broke the more rigid amphibolite "bands" into fragments and encircled

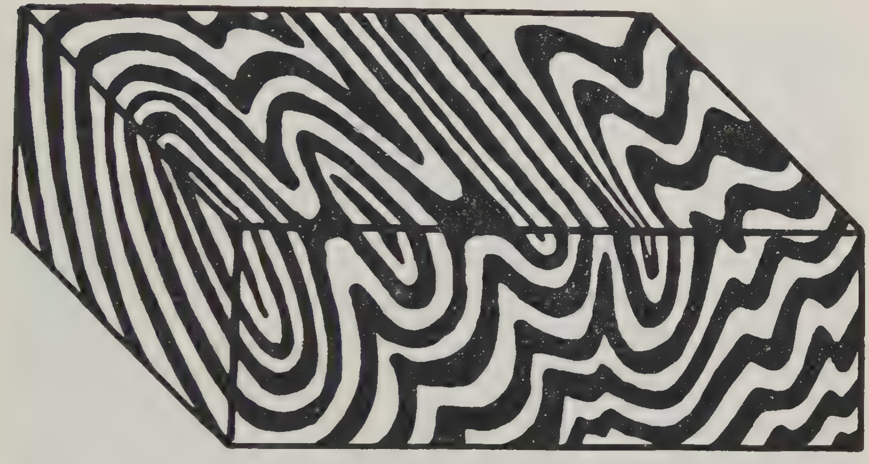

Fig. 3. The effect of different orientation of the folding axes in banded gneiss.
To the left: Axes pitching 50—60° SW.
In the middle: Axes horisontal.
To the right: Axes pitching 30° NE.

them. The foliation is always concordant with the contours of the fragments.

When the amphibolites obtained a certain degree of plasticity they did not break, but were folded in a way rembling the ptygmatic folding.

This zone of plastic deformation I have called *the special migmatic zone* of the banded gneisses. (Observed at Halvorshl.,Torungen, Spærhl.)

The true ptygmatites consist of strongly folded, narrow, granitic or aplitic dikes lying in a still more acid rock, usually of a massive structure. They are common in the migmatite-zones of the banded gneisses.

The origin of the ptygmatites has always been a matter of discussion. In the present area they probably were formed through plastic deformation of straight aplitic dikes, in the same manner as mentioned for some of the amphibolite folds. Before the rocks reached the condition of plastic deformation they passed through a zone where fracturing took place. For instance, at Indre Torungen we may see how aplitic material filled straight, parallel fractures, originated through folding-faults (Pl. II, Fig. 3).

By the following plastic deformation the dikes became more rigid than the country-rock, and the ptygmatites developed.

Experimental investigations also support this explanation (O. M. Erdmannsdörfer 1938).

4. Limestones.

The limestones between Grimstad and Kristiansand have been described by Olaf Holtedahl (1917). He mentions their stratification and is in favour of a sedimentary origin. The several occurrences (Hærøya, Rivingen, Fladerivingen, Maløy etc.) show great resemblance, and Holtedahl thinks they represent nearly the same stratigraphical horizon.

They appear chiefly in a narrow zone along the coast in north-east—south-western direction and seem to be limited to areas of banded gneisses. At Esketveid on the opposite (north-east) side of the Grimstad granite the limestone-zone appears again in the strike direction, and can now be followed as a strongly folded skarn-limestone zone for several kilometers in NE direction (Fig. 14). Occasionally, the limestone is still preserved (Ranneklev, Nøddebro, Klodeborg), but is usually replaced by skarn minerals and iron ore. Some of the best-known deposits of iron ore occur within this zone, thus indicating a genetic relation between the limestone and the ore.

The limestones often appear as thin layers alternating with quartzitic and dioritic gneisses (gneiss-banded limestones). The origin of the last-mentioned dioritic rocks is uncertain, for their chemical and mineralogical composition is often changed through reaction with the limestones. Small dark stripes, chiefly containing biotite, often indicate highly metamorphic sandstones.

Occasionally we find greater masses of limestones. The island Fladerivingen (200 m long and 100 m broad) chiefly consists of limestone. It has broken up younger amphibolites and granitedikes and flowed around the fragments as a plastic mass, filling every crack and fracture (Fig. 4) without any marked reaction on the contact.

Certainly the limestone does not lie in the place where it was first formed. By elevated temperature and under sufficient differential stress the limestone yielded in a quasi-plastic fashion. Solution took place where the pressure was sufficiently high, and the material was deposited at other places where the pressure was weaker, thus causing a gradual deformation of the rock (Riecke's principle).

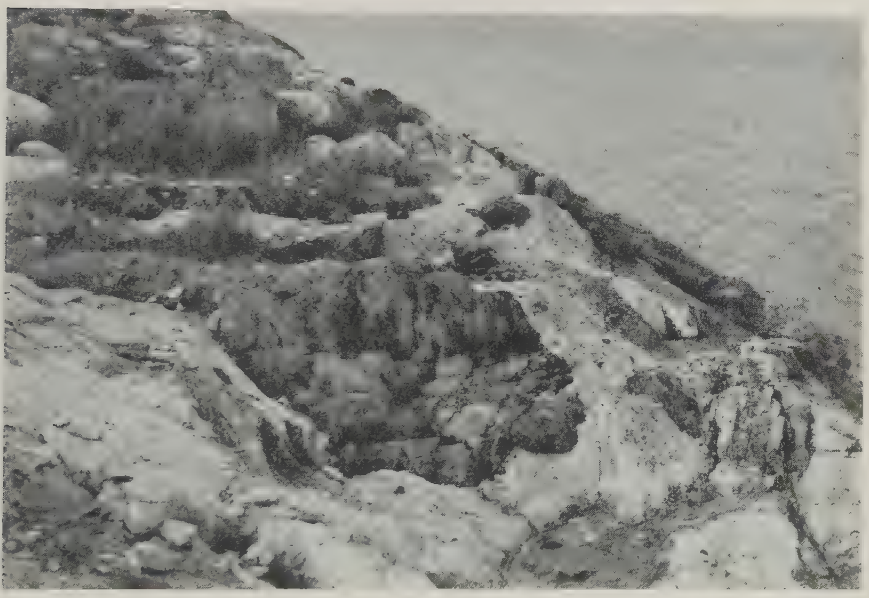

Fig. 4. Plastic deformation in limestone. Fladerivingen SW of Grimstad.

In order to explain the comparatively great size of the deposit (Fladerivingen) it seems most probable that it developed from a gneiss-banded limestone situated at a somewhat deeper level. Due to differential stress, the limestone was squeezed along the bedding- or foliation-planes, fractures etc., occasionally concentrating to greater masses.

5. Hyperites.

Hyperites are known from many parts of the Bamble formation. In the north-western part of the district they appear as coarse-grained abyssal masses. Further south-east they occur as dikes of varying size, from some meters to 50—60 meters breadth. Following the strike of the country rock, we find on the coast a broad zone of hyperite-dikes and bodies. On Tromøy, one of the dikes was followed about 6 km from Kongshavn to Færvig. Large dikes are also seen on the southern parts of Hisøy and Gjervoldsøy, on Mærdø, inner Torungen, Ærø, Bratthl., Halvårshl., and Hasleodden where they are cut off by the Grimstad granite, appearing again on the islands on the opposite side of this granite. Important indications of the intrusive character of the hyperites are the mineralized zones (fahlbands) in the country rock near the contact. The hyperites are younger than the supra-crustal rocks and have forced their way up, cutting the banded gneiss (fig. 5). The rocks are medium- to coarse-grained, showing ophitic structure. The unmetamorphic types contain plagioclase, monoclinic and rhombic pyroxene, some amphibole, spinnelide, magnetite, apatite, garnets etc. The plagioclase may constitute about 50 vol. per cent of the rock and contains from 40—70, usually about 50 per cent An. The crystals are lath-shaped, displaying most of the feldspar twins, possibly with albite and pericline twins in preponderance. The second main mineral in the south-eastern district is a pigeonitic pyroxene, forming a mesostasis between the other minerals, often including them.

The optical properties for two pyroxenes (from Tromøy) measured on the Fedorow stage are as follows: (1) Pigeonite $+2\,V_{Na}=16^{\circ}$, $c:\gamma_{Na}=39^{\circ}$, $\alpha_{Na}=1.690$, $\angle\ (110)\sim 93^{\circ}$. The plane of the optic axes is (010). The pyroxene contains small brown interpositions of ilmenite (?) ǂ 100.

2. Augite $+2\,V_{Na}=52^{\circ}$, $c:\gamma_{Na}=44^{\circ}$.

After Winchell (1935) the composition should be:

	Pigeonite	Augite
Diopside	14	30
Hedenbergite	6	30
Clino-enstatite	56	20
Clino-hypersthene	24	20

The pyroxenes are often zoned with decreasing CaO from the core towards the periphery. They often exhibit a fine lamellation parallel to the plane of the optic axes, resembling the perthite structures, formed by exsolution of homogeneous mix-crystals. The crystals show great resemblance to the augite—perthite described by W. Wahl (1907, 1908) and it is probable that they represent a stage in the unmixing of a pigeonite. Recent investigations (T. F. W. Barth 1936, Tsuboi 1932) indicate that pigeonites only appear in the intrusive and effusive, but not in the abyssal stage of a rock. Being stable only at high temperature they exist at normal temperature metastably. With increasing temperature under metamorphism, they will tend to unmix, thus giving one diopsidic and one enstatitic pyroxene

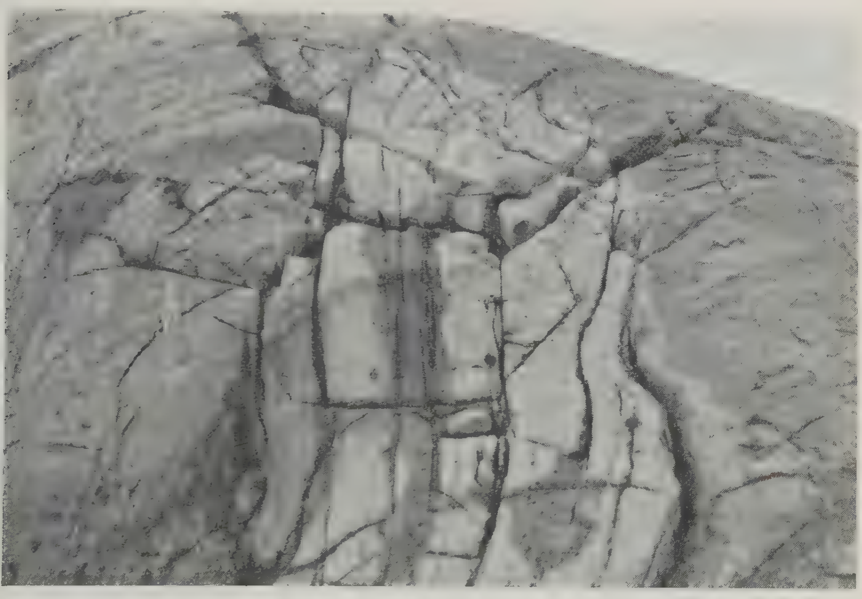

Fig. 5. Hyperite cutting banded gneiss. Ærø.

Between pyroxene and plagioclase a corona structure is usually encountered. From the pyroxene and outward the coronas are composed of hypersthene, brown hornblende, and garnet (Pl. II, Fig. 4).

In the hyperites of the north-western district I have never found pigeonitic pyroxene. Instead they contain augite and hypersthene, often resembling the Kragerø hyperites, so excellently described by W. C. Brøgger (1935).

Through later processes the hyperites are often amphibolitized, the larger bodies only in the peripheral parts, the smaller ones often completely.

6. Arendalites[1] (Charnockite-rocks, Urgranite).

These rocks range in composition from norites and hypersthene diorites to charnockites and granites. Both the chemical and the mineralogical composition testify to a direct consanguinity between the several types. They are related in space and time, reaching from Søndeled to Øiestad.

---

[1] These rocks, being of metasomatic origin, will be given a more detailed description in another paper.

Hypersthene granites from Søndeled was first mentioned by Olaf Andersen. The wide distribution of the hypersthene diorites and hypersthene granites was pointed out by Carl Bugge who has carried out most of the field investigations.

It is difficult to distinguish these rocks — which often show a gneissic structure — from the other gneisses with which the arendalites always form a broad transitional zone, consisting of rocks that I have called *border-migmatites.*

The arendalites have the peculiar brownish to greenish colour as commonly observed in the monzonite — charnockite rocks. Usually they are medium-grained, showing an equigranular, hypidiomorphic texture, which in the metamorphic facies may be granoblastic to gneissic.

The Basic Division (ca. 48—55 % SiO_2).

The basic members of this series usually appear in the intermediate and acid rocks as flakes or diffuse dikes of varying size. They wedge out along the strike (ca. NE—SW) and can seldom be followed over greater areas.

The types vary from gabbros, norites and jotun norites to hornblende gabbro and amphibolites.

Table 1 shows the analysis of a typical hornblende norite from Solbakken, Langsev (Pl. III, Fig. 5).

The mineral content is plagioclase, amphibole, hypersthene, magnetite, apatite, some secondary quartz, and scapolite.

The plagioclase is determined $\perp \alpha$ by the extinction

$$\beta : 010 = +13^\circ, \text{ giving } Ab_{70}\, An_{80}.$$

The hypidiomorphic crystals, having both albite and pericline twins, show signs of cataclastic deformations and are often broken or bent. Sometimes they are changed to a strongly pigmented mass for which no optical datas can be given. This mass contains small grains of scapolite and seems to represent a stage in the replacement. Since no calcite is visible, the CO_2 (0.55 %) is probably concealed in the small inclusions of the pigmented mass.

The essential dark minerals are greenish-brown hornblende and ortho-rhombic pyroxene. Hornblende often surrounds pyroxene which it also replaces (Pl. III, Fig. 6). The extinction $c : \gamma_{Na} = 17^\circ$; the angle of the optic axes $= 2V \sim 80^\circ$. The pleochroism is: $\gamma =$ dark

Table 1.

	Weight $^0/_0$	Molprop. × 10000	Norm	Niggli
SiO_2	49.28	8172	or 3.28	si 113
TiO_2	1.30	162	ab 35.89	al 20
Al_2O_3	14.77	1445	an 21.51	fm 49
Fe_2O_3	4 30	269		c 21
FeO	8.74	1216	Σ sal.... 60.32	alk 10
MnO	0.24	34	wo 7.25	k 0.08
MgO	6.76	1677	en 3.86	mg 0.48
BaO	0.02	1	fs 2.48	si^1 140
CaO	8.31	1481	fo 9.04	qz −27
Na_2O	4.25	685	fa 6.42	
K_2O	0.56	59	ap 0.84	
H_2O-	0.09	50	il 2.50	
H_2O+	0.47	261	mt 6.26	
P_2O_5	0.35	25		
CO_2	0.55	125	Σ fem... 38.65	
S	0.04		H_2O.... 0.56	
			CO_2 .... 0.55	
	100.03			
			Sum ... 100.08	

Anal. Ing. Klüver.

brownish green, β = brown, α = pale yellowish brown. $\gamma > \beta > \alpha$. The refractive indices as determined by the immersion method are:

$$\gamma_{Na} = 1.682, \quad \alpha_{Na} = 1,660.$$

According to the tables of Esper Larsen the composition will be about: $Ca_4Na_2\ (Mg, Fe)_9\ (Al, Fe)_4\ Si_{18}O_{44}\ (OH)_4$

$$\text{where } \frac{Mg}{Fe} = 1.4, \quad \frac{Al}{Fe} = 4.8$$

Hypersthene. The angle between the optic axes is $2V \sim 65°$, the pleochroism γ = pale bluish green $\beta \sim \alpha$ = pale pink. The refraction index $\gamma_{Na} \sim 1.695$ thus giving a hypersthene $en_{79}\ fs_{21}$.

The Intermediate Division (ca. 55—65 $^0/_0$ SiO_2).

Table 2 shows the analysis of a more basic member of this division, a gabbro from Neskilen, Tromøysund.

The mineral content of this gabbro is plagioclase, ortho-rhombic and monoclinic pyroxene, hornblende, quartz, apatite and magnetite.

Table 2.

	Weight %	Molprop. × 10000	Norm	Niggli
SiO_2	55.15	9144	Q 6.99	si 148
TiO_2	0.95	119	or 3.11	al 26
Al_2O_3	16.45	1610	ab 30.76	fm 42
Fe_2O_3	2.77	173	an 26.98	c 21
FeO	6.90	960		alk 11
MnO	0.15	21	Σ sal . . . 67.84	k 0.09
MgO	5.14	1275	wo 2.83	mg 0.49
CaO	7.30	1301	en 12.75	si^1 144
Na_2O	3.64	587	fs 8.82	qz 4
K_2O	0.53	56	ap 0.91	
P_2O_5	0.38	27	il 1.81	
H_2O	0.25	139	mt 4.01	
	99.51		Σ fem . . . 31.13	
			H_2O 0.25	
			Sum . . . 99.22	

Anal. J. Bugge.

The plagioclase, forming hypidiomorphic crystals, is determined $\perp \alpha$ by the extinction angle $\beta : 010 = +19°$ giving Ab_{63} An_{37}.

The rhombic pyroxene has the following optic properties:

Pleochroism: γ=bluish green, β=yellowish brown, α=pale pink refractive index $\gamma \sim 1{,}710$ thus giving a hypersthene: en_{72} fs_{28}.

It often shades into monoclinic pyroxene without sharp borders.

The monoclinic pyroxene has the optic angle $+2V = 60°$, extinction angle $c : \gamma = 45°$ and refractive index $\gamma_{Na} = 1.723$ and may thus be a diopsidic pyroxene with about 45 weight perc. hedenbergite.

The hornblende has the following optical properties: $-2V_{Na} \sim 80°$, $c : \gamma_{Na} = 21.5$, refractive indices: $\gamma_{Na} = 1.680$, $\alpha_{Na} = 1.659$ and pleochroism γ=dark green, $\beta \sim \alpha$=yellowish green.

The composition of this hornblende is very close to that described on page 83.

Biotite, with refraction index n = 1.642 on cleveage flakes and pleochroism γ and β dark brown, α — pale brown, is of minor importance.

Table 3.

	Weight 0/0	Molprop. × 10000	Norm		Niggli
SiO_2	64.59	10711	Q 13.83		si 229
TiO_2	0.71	89	or 4.23		al 31
Al_2O_3	14.80	1448	ab 52.71		fm 38
Fe_2O_3	2.05	128	an 8.55		c 8
FeO	4.95	689	c 0.67		alk 23
MnO	0.16	23			k 0.07
MgO	3.35	831	Σ sal....	79.99	mg 0.46
BaO	0.04	3	en 8.31		si^1 192
CaO	1.96	349	fs 6.53		qz 37
Na_2O	6.24	1006	ap 0.44		
K_2O	0.72	76	il 1.35		
H_2O-	0.10	55	mt 2 97		
H_2O+	0.24	133			
P_2O_5	0.19	13	Σ fem...	19.60	
CO_2	tr.		H_2O ...	0.34	
S	0.06				
	100.16		Sum ...	99.93	

Anal. Ing. Klüver.

Table 3 represents the analysis of an acid member of the intermediate division, a quartz-hypersthene diorite (arendalite) from Solbakken, Langsev (2 meters south of the hbl. norite described page 82).

It contains plagioclase, quartz, hypersthene, some biotite, magnetite and apatite. The plagioclase determined $\perp \alpha$ by $\gamma : 001 = +7°$ gives Ab$_{86}$ An$_{14}$. The crystals are often broken or bent, and have albite and pericline twins. The quartz is highly pigmented and shows undulating extinction.

The hypersthene has the optical angle $-2V_{Na} = 60°$, pleochroisme γ — bluish green, β — brown, α — pale pink and refraction index $\gamma_{Na} \sim 1.713$ corresponding to a hypersthene en$_{70}$ fs$_{30}$.

The other minerals are of accessory importance.

The intermediate division includes a great variety of rocktypes, all characterised by rhombic pyroxene and an acid plagioclase often being antiperthitic (Fig. 6).

In the same rock we may find feldspars of different composition, andesine or obigoclase, antiperthitic acid plagioclase, perthite and microcline. Several types exhibit an astonishing similarity to rocks of the charnockitic tribe of the Egersund district and of the Bergen—Jotun tribe of the Norwegian Caledonian igneous series.

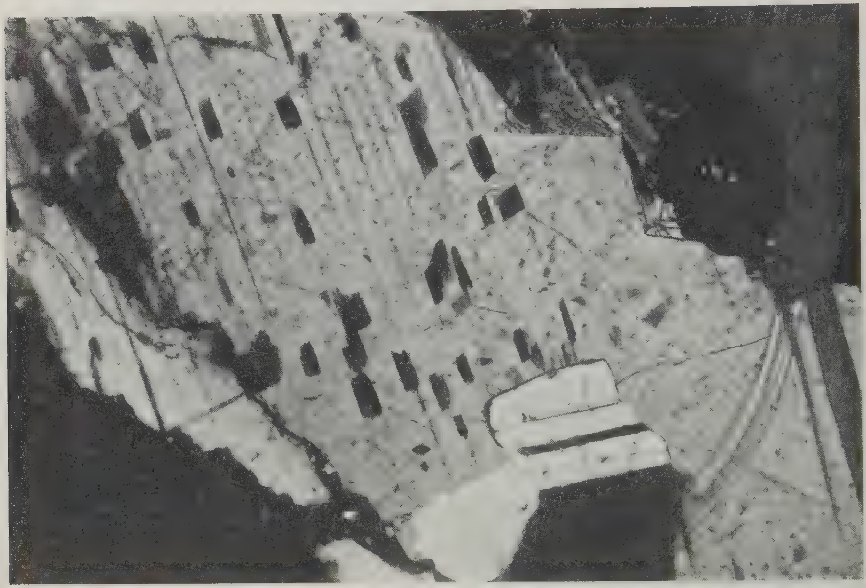

Fig. 6. Antiperthite in Arendalite. ×60, nic. crossed.

The quartz-hypersthene diorite with acid antiperthitic plagioclase, I have called *arendalite* because it is typical of the Arendal district and represents a member of the charnockite series which apparently is in want of a new name.

From enderbite, described by Tilley (1936), it is distinguished by a more acid, antiperthitic plagioclase. The content of hypersthene ranges from 10—20 %, that of quartz around 20 %, whereas enderbite exhibits 3 % and 42 % respectively.

The Acid Division (> 65 % SiO_2).

The intermediate rocks pass continuously into the acid types with members corresponding to every stage in the transition. Table 4 represents the analysis of a typical charnockite from the Langsev mining district.

This rock contains plagioclase, perthite, quartz, hypersthene, biotite, magnetite and apatite.

The plagioclase is determined $\perp$ PM and varies in composition from 8—12 % An, more acid when containing antiperthitic spots of potashfeldspars than in pure plagioclase.

Table 4.

	Weight %	Molprop. × 10000	Norm		Niggli
SiO_2	70.28	11655	Q 20.36		si 314
TiO_2	0.26	32	or 11.01		al 38
Al_2O_3	14.40	1409	ab 55.18		fm 25
Fe_2O_3	1.89	118	an 3.52		c 3
FeO	2.62	365	C 0.42		alk 34
MnO	0.14	20			k 0.16
MgO	1.17	290	Σ sal....	90.49	mg 0.32
CaO	0.71	127	en 2.90		si^1 248
Na_2O	6.53	1053	fs 3.10		qz 66
K_2O	1.87	198	ap 0.10		
P_2O_5	0.04	3	il 0.49		
H_2O	0.22	22	mt 2.74		
	100.13		Σ fem...	9.33	
			H_2O ...	0.22	
			Sum ...	100.04	

Anal. Jens Bugge.

Antiperthite determined $\perp \gamma$ by $\alpha : 001 = +16°$ gives Ab_{92} An_8.

The Hypersthene has the following optical properties:

The optic angle $-2V_{Na} \sim 60°$, pleochroisme:

γ = bluish green, $\beta \sim \alpha$ = pale pink and refraction index $\gamma_{Na} \sim 1.717$ corresponding to a hypersthene en_{67} fs_{88}.

The biotite has the pleochroisme γ and β dark brown α — colourless, The refractive index, measured on the cleavage flakes: $n = 1.641$. The flakes commonly are surrounded by an opazite border, constituted of rutile and magnetite, formed through resorbtion of the biotite.

The acid division also includes a great variety of rock types, quartz—hypersthene diorites, charnockites, biotite or amphibole granites etc. They are characterized by a strongly perthitic feldspar (Pl. IV, Fig. 7), but contain, usually, feldspars of different compositions as mentioned also for the rocks of the intermediate division. Where plagioclase borders to potash feldspar it is common to find myrmekite (Pl. IV, Fig. 8).

It is proposed that rocks of the whole series, ranging from the basic to the acid division, be called *arendalite rocks*.

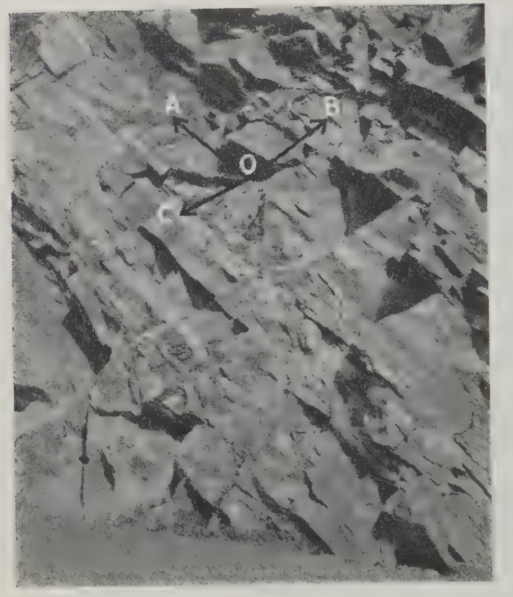

Fig. 7. Arendalite, Strømmen, Hisøy.

Tectonics.

The main cleavage directions are shown by the cross O—A B C in the Fig. 7. The strike and the dip are always observed parallel to the plane O A B. The strike varies about N 30—40° E and the dip 50—70° SE and are parallel to the foliation planes of the country rocks. The fractures parallel to C O B (flat-lying cross joints) are often filled with pegmatite dikes of a thickness varying from some cm up to several meters.

As mentioned above, the arendalites pass through the broad zone of border-migmatites into the country rocks. When we cross the strike we find quartzite, amphibolite, granite, and arendalite in alternating bands or zones. Even in the central parts of the arendalite it is not unusual to find relics of the older rocks. The ore districts Solberg, Torbjørnsbo, Langsev, are, for instance, such relics of the old complex.

It is interesting that the arendalite sometimes shows eruptive character indicating a magma, which has forced its way upward, pushing the other rocks away, while at other places, especially in the south-eastern part it continuously passes into the banded gneisses.

7. Quartz—Biotite Diorite.

The diorite south-west of the Grimstad granite is on the map marked in the same way as the arendalite. The rocks are massive, greyquartz diorites with abyssal character. On the coast they pass continuously into banded gneisses and migmatites. They are not yet studied in detail, but probably represent members of the arendalite series. They correspond to the coastgranite of Arne Bugge.

8. Granites.

In the Arendal district we can distinguish between the following types of granitic rocks[1]:

1. The oldest red granites.
2. The granite pegmatites.
3. The Grimstad granite.

The Oldest Red Granites.

The large bodies of granites with abyssal character are chiefly situated in the northern or north-western part of the district. From the coast towards north-west they increase in amount and size, until at Nelaug we meet the great Telemark granites.

As usual for migmatite granites, they pass through a broad transitional zone into the surrounding rock types. In the southern parts of the Arendal district (Fig. 13), the granites only form dikes of varying size, usually following the strike of the countryrocks. The largest of them are usually accompanied by swarms of smaller dikes.

The granitic liquors have often caused a marked granitization in the pre-existing rocks, the dikes therefore are usually accompanied by broad zones of injection gneisses.

The dikes of granite are medium- to fine-grained. From the ore district T. Dahll (1861) describes them as red quartzites.

The chief constituents are microcline and quartz, subordinary plagioclase, biotite, diopside, magnetite etc.

The most frequent of the dark minerals is biotite, but this depends to a certain degree upon the composition of the country rock. When the dikes cut zones of skarn they may for instance contain diopside, titanite, epidote etc. instead of biotite.

The Granite Pegmatites.

Pegmatites have a wide distribution and are found in all the rocks mentioned, as "schlieren", dikes or big masses occupying several hundred m^2. In the migmatic and gneissic areas schlieren gneisses (arterites) are very common. The pre-existing rocks have been quite infiltrated with granitic liquors (ichor) that partly caused a feldspathization and partly segregated as schlieren. It seems impossible to regard the granitic material as formed by differentiation of a magma. A palingenic origin (at a deeper level) in the manner proposed by Sederholm is more reasonable. The observations of T. F. W. Barth (1930) and Olaf Andersen (1931) are also in accordance with this mode of origin.

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[1] Here is not included the charnockites, which are described under the acid division of the Arendalites.

During discussion of the origin of the small pegmatite bodies (the Arendal district) in the Bamble formation, O. Andersen writes: "In view of these facts the conclusion seems necessary that all this communication between the magma and the openings where pegmatites are formed, either inside or outside the granite, to a large extent has taken place through very narrow channels. Further evidence for this conclusion is found in the following circumstances: The small cracks now filled with pegmatite have no visible interconnecting channels, and the granites with their adjacent rocks show very few traces of large, continuous openings through which a widespread communication between the magma and its surroundings can have taken place. The pegmatites in general give the impression of being closed bodies, the openings giving access to the liquids from which they crystallized must have been of such fineness that they escape detection by field methods, they may have been almost capillary continuations of unvisible cracks. This, in my opinion, constitutes one of the fundamental differences between pegmatites and ordinary igneous dikes and is a point to be considered when the genesis of pegmatites is discussed."

The dikes may be from a few dm up to several meters thick, and it is common to find pegmatitic and aplitic dikes in close connection. They transverse the rocks in several directions, often filling flat-lying joints, striking about NW—SE and dipping 20—30° NE. In the mine Torbjørnsbo we find four such parallel dikes, the distances between them being some meters.

The big, coarse-grained bodies of pegmatite are very interesting. They often appear in connection with hyperites and are frequently seen near the borders of the great areas of quartzite. At Løddesøl they can be followed several hundred meters as small ridges, 50—60 m broad. It is significant that these great masses occur in close connection to the quartzites. As mentioned, the quartzites commonly resist granitization and often seem to be impervious to the granitic liquors (ichors). When these liquors on their way upward met with large quartzite bodies they could not soak through them, but had to flow around, thus forming accumulations around the edges of the quartzite bodies. Now they are seen in the terrain as long ridges surrounding the quartzite areas. (For a more detailed description of pegmatites from the southern Norway see O. Andersen (1928, 1931), T. F. W. Barth (1928), W. C. Brøgger (1906, 1922)).

The Grimstad Granite.

This granite occupies a circular area (about 50 km^2) east of Grimstad. It is a red, coarse-grained granite of a uniform structure. In addition to the main rock type we find smaller areas of more basic rocks, genetically connected with the main type, but older than this. They are situated in the strike directions of the great amphibolite dikes at the coast and, probably, they are formed through assimilation of material from these rocks. Even if they are formed in this way they may very well look like rocks formed by fractional crystallisation.

Except for the dikes of diabase and the great dikes of rhomb-porphyry, the Grimstad granite is the youngest rock in the Bamble formation. Usually it displays a sharp eruptive contact against the older rocks, with vertical borders. (For a more detailed description see I. Oftedahl 1938.)

9. The Regional Migmatites.

Between the north-western quartzite—hyperite formation and the southern arendalites lies a broad zone with migmatic rocks, viz. alternating bands of quartzites, amphibolites, arteritic gneisses, granites etc. The zone represents the supra-crustal rocks, amphibolites etc. in highly metamorphic facies. I have called the rocks *regional-migmatites* as distinct from the above-mentioned border- or contact-migmatites (pag. 82). Both of them are formed by melting and migmatization in connection with injection of magmatic solutions, which in the regional-migmatites were usually of granitic composition. The processes may be analogous to the *regional- and contact-metamorphism*, but have proceeded at deeper levels of the earth's crust.

Since these rocks appear in a rather intimate connection, I have not, on the map, usually distinguished the different rocks.

We find rocks resembling the banded gneisses of the coast, but the best indication of pre-existing supra-crustal rocks in the district is given by the skarn zones.

10. The Skarn Zones.

Under the general description of the rocks, I have mentioned the deposits of skarn and limestone in the zones of the regional-migmatites. They occur alternating with quartzitic, dioritic, amphibolitic and granitic rocks. Certainly we here have a formation of sedimentary mode of origin.

The deposits of iron ore are situated in these zones and the limestones have been of major importance for the genesis of the iron ore. There exist transitions between the limestone and the skarn, and the mineral parageneses of the skarn indicates that it represents contact metamorphic limestones.

The longest zone (see Fig. 14) is followed continuously over a distance of 7 km, viz. from Klodeborg to the Grimstad granite. Since the last 400 meters are covered by quaternary deposits, I could not find the exact borders. The zone appears again on the islands south-east of Grimstad. North-eastward it can be followed discontinuously ca. 7—8 km from Klodeborg to Solberg, Torbjørnsbo and Langsev. Deposits of limestone are also known both farther to the south-west and farther to the north-east, making altogether a total length of 40—50 km (the main skarn zone).

Other than this chief zone, we find smaller limestone areas, in zones nearly parallel to the chief zone. At Løddesøl, near the border of the quartzites and the regional migmatites, I have found a zone of skarn and limestone which I have followed for 300—400 meters north-eastward.

Near the road ca. 1 km north of Bjorbekk in Øiestad limestone is also found.

On Fig. 14 I have marked the mines of the chief zone. When we count all the shafts, the big as well as the small ones, there are about 100 between Esketveid and Klodeborg.

The rocks of the skarn zone pass by gradation into the surrounding rocks.

II. The Main Skarn Zone.

1. Mineralogy.

The most important minerals of the skarn deposits are: monoclinic pyroxene, garnet, vesuvianite, amphibole, epidote, zoisite, phlogopite, biotite, magnetite, scapolite, tourmaline, apatite, titanite, serpentine, rhodonite, pleonaste, babingtonite, datolite, analcime, pyrite, and chalkopyrite.

Pyroxene.

Monoclinic pyroxene is one of the most important skarn minerals. When together with garnet in the coccolite-kolophonite skarn it contains more iron than when it is encountered in contact with calcite and magnetite.

The optical properties of pyroxenes belonging to the coccolite type are: Axial angle: $+2V \sim 60^\circ$, extinction angle: $c : \gamma_{Na}$ 43—44°. The refractive indices were measured by the immersion method in Na — light:

Langsev $\alpha = 1.700$, $\gamma = 1.720$
Torbjørnsbo $\alpha = 1.695$, $\gamma = 1.720$
Lærestveid $\alpha = 1.690$, $\gamma = 1.715$.

The colour is pale green to olive-green. Pleochroism cannot usually be seen.

The data correspond to a diopsidic pyroxene with 37—50 weight % hedenbergite, but small irregularities in the properties indicate small percentages of sesquioxydes; they seem, however, to be of minor importance. In an analysis of a coccolite (from ca. 1910) Doelter gives the following percentages:

Al_2O_3 1.37 weight %, Fe_2O_3 1.08 weight %.

The pyroxene of the diopside type is pale green to colourless. The extinction angle varies from 38—41°, and the optic angle $2V = 60^\circ$. The following data were determined on a pyroxene from Klodeborg: $+2V = 60^\circ$, $c : \gamma = 38.5$, and refractive indices $\alpha_{Na} = 1.670$, $\gamma_{Na} = 1.700$ corresponding to a diopside with 9 weight % hedenbergite.

Garnet.

Kolophonite is the predominating garnet. It is of a reddish brown colour and occurs usually together with coccolite in holohedral crystals of 1—5 mm diameter. The approximate composition can be deduced from the specific gravity and the refractive index. I used Clericis solution and Mohr-Westphals balance to determine the specific gravity, and the immersion method for the refraction index.

No. 1 Langsev n=1.83, sp.gr.=3.68
No. 2 Nøddebro n=1.83, sp.gr.=3.80
No. 3 Klodeborg n=1.83, sp.gr.=3.80

Number one corresponds to $An_{60}Gr_{40}$ and the other two to $An_{45}Gr_{86}Al_{23}$ (An=andradite, Gr=grossular, Al=almandine).

In the ternary diagram of Philipsborn (1928), the garnets would have a composition marked by the dark triangle of fig. 8. It is not unusual to find grossular—andradite garnets and pyropealmandine garnets together. The last-mentioned type commonly occurs in the amphibole schists and in the amphibolites.

Vesuvianite.

Vesuvianite seems to be a rare mineral in the skarn deposits. I have only found it at Nøddebro where it occurs with calcite, diopside and garnet. On account of its reddish brown colour, it may be confused with garnet. It is anomalously biaxial, positive with a very small optic angle. Birefringence weak and refractive index, n—1.705. Certainly it is one of the oldest skarn minerals.

Amphibole.

The amphiboles belong to two different series:

1. Tremolite—actinolite.
2. Common hornblende.

The tremolite—actinolite minerals are of less importance in the ore deposits. They are chiefly found in those deposits of limestone where metasomatic processes played a minor rôle (e. g. Løddesøl and the islands SW of Grimstad).

The hornblende skarn frequently follows the granite dikes, representing a reaction product between the granite magma and the older skarn.

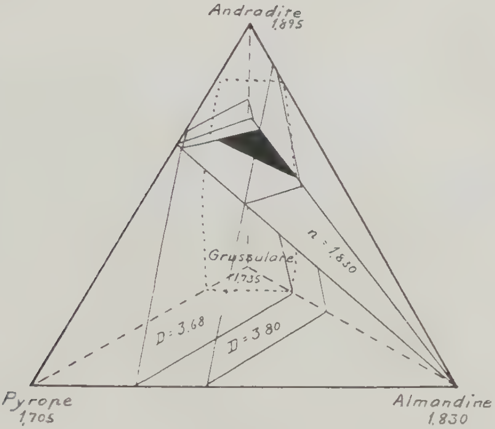


Fig. 8.

In hornblende—epidote—plagioclase—skarn from Lærestveid I made the following observations: The optic angle $2\,V_{Na} \sim 80^\circ$, extinction angle $c : \gamma = -18^\circ$, pleochroism: α = pale yellow, β = green, γ = bluish green.

refraction indices $\alpha = 1.633$, $\beta = 1.640$, $\gamma = 1.653$.

Disregarding Al_2O_3 the tables of Winchell give the composition:

$Ca\,Mg_2\,Si_2O_9$ = 80—85 weight %
$Ca\,Fe_2\,Si_3O_9$ = 2— 7 weight %
$Na\,FeSi_2O_6 + Fe_2O_3$ = 12—15 weight %

Epidote.

In some of the iron ore deposits, epidote is one of the most important skarn minerals. The green prismatic crystals may be 5—10 cm long and are elongated parallel to the b-axis, but the epidote is often found in dense masses too. Epidote from Solberg: Optic angle $-2\,V$ large, pleochroism: α and β = colourless, γ = pale yellow, refractive indices:

$$\alpha = 1.731, \ \beta = 1.750, \ \gamma = 1.761.$$

This corresponds to a composition

$(OH)\,Ca_2\,Al_2Si_3O_{12}$ 77 mol %
$(OH)\,Ca_2\,Fe_3\,Si_3O_{12}$ 23 mol %

Mica.

The mica-skøls or skarns form short "bands or dikes" among the other skarns. The predominating mica minerals are phlogopite and normal biotite. I have determined a phlogopite from calcite—phlogopite skarn, Langsev: It is nearly colourless and the pleochroisme faint. The optic angle —2 V = 1—2°, and the refractive index determined on cleavage flakes n=1.605. According to Winchell's diagram the composition is:

Phlogopite	38	mol %
Eastonite	38	—
Annite	12	—
Siderophyllite	12	—

Biotite from a skøl at the Tengstevid deposit has the pleochroism γ and β: brown, α: pale yellow and is biaxial negative, —2 V very small.

The refractive index on cleavage flakes, n=1.625, corresponds to a normal biotite with ca. 25 % of each of the four constituents.

Magnetite.

Magnetite seems to be the only ore mineral present in the ore deposits of the Arendal district. However, determinations with the ore microscope have not yet been made and the ore may contain a little hematite. The ore usually forms steeply dipping stocks or lenses in the more central parts of the deposits.

The ore has brecciated the coccolite—kolophonite skarn (see J. H. L. Vogt, 1908, 1918) and is certainly younger than the skarn. Nearly all the mines are water-filled and, therefore, usually it is not possible to investigate the ore in detail. For some of the mines we have a description by J. H. L. Vogt, who also deals with the production and other economic relations. I have taken from his book the analyses (1906) published on page 27:

	Klodeborg	Torbjørnsbo	Langsev
Fe_3O_4	66.30	73.56	60.79
SiO_2	11.30	11.50	23.28
Al_2O_3	1.20	3.75	2.76
MnO	1.95	0.87	0.78
CaO	9.20	7.20	10.93
MgO	6.90	2.46	4.08
P_2O_5	0.06	-	-
S	0.82	0.032	-
Sum	97.73	99.37	102.92
Fe	48.9	53.29	44.02
P	0.035	0.018	-

Klodeborg

Fe_2O_3	47.36	Cu.	traces
FeO	17.00	Pb.	-
MnO	1.95	As	0.017
SiO_2	11.40	S	0.041
Al_2O_3	1.20	P_2O_5	0.032
CaO	9.00	CO_2	4.60
MgO	6.15	H_2O	0.55
BaO	-		
TiO_2	0.28	Sum	99.99
ZnO	0.013		
NiO, CoO	0.18	Fe	46.45
		Mn	1.55
		P	0.014

Vogt also gives the following averages from Klodeborg:

Fe	43—49 %
P	0.063 %
Mn	1.70—2.00 %
Zn	0.25 %

Scapolite.

Scapolite frequently occurs in dense, greasy masses as small veins in the skarn, but scattered small prismatic crystals can also be seen.

Optical constants for scapolite in a small vein from a coccolite—kolophonite skarn at Langsev are:

Uniaxial negative, refractive indices:

$$\omega = 1.570, \ \varepsilon = 1.545.$$

This corresponds to the composition

Marialite 56 mol %, Mejonite 44 mol %.

At Alvekilen scapolite occurs in connection with magnetite, monoclinic pyroxene and saussuritised andesine. It shows transitions to the feldspars and is secondary after this mineral. Probably it originated a little later than the ore because small veins of scapolite are found in the ore (fig. 9).

Tourmaline.

Tourmaline is a rather rare mineral. It forms black crystals a few cm long in the skarn at Klodeborg and Alvekilen. It is uniaxial negative, with pleochroism ω = dark green, ε = pale grey and refractive indices:

$$\omega = 1.650, \ \varepsilon = 1.625$$

corresponding to a schorlite composition.

Titanite.

Titanite occurs in microscopically small crystals in several skarns. Occasionally the crystals obtain a size of 1—2 cm.

Apatite.

The small, clear blue crystals always occur in the iron ore. They are uniaxial negative with refractive index $\omega = 1.640$.

In addition to the minerals mentioned, several others occur. They are not dealt with in this paper, but would certainly be of great interest for a more comprehensive description of the parageneses than it is the intention to present here.

2. Petrology.

Skarn, originally, is a Swedish term for the rather coarsely crystallized silicates which frequently occur as gangue minerals together with iron ore and commonly associated with limestone.

At the Arendal skarn deposits we can distinguish the following types:

Coccolite—kolophonite	skarn
pyroxene (diopside)	„
garnet (chiefly kolophonite)	„
amphibole	„
epidote—zoisite	„
mica	„
scapolite	„

Thorolf Vogt (1937) has classified the skarn iron ores according to the dominant silicate minerals.

1. Garnet and monocline pyroxene, some spinnelides. The Torbjørnsbu type. Resembling the Persberg type of Harald Johanson.
2. Monocline pyroxene with some calcite, scapolite and spinnelide. The Klodeborg type.
3. Monocline pyroxene and hornblende with or without calcite, epidote, and scapolite. The Bråstad-Lærestveid type. Resembling the Björneberg type of Harald Johanson.
4. Calcite with some biotite and clorite. Ore from Solberg at Arendal. Resembling ore from Skärstöten.
5. Serpentine. Ore from Bråstad. Resembling the Bergsäng—Gubbotype of Harald Johanson.

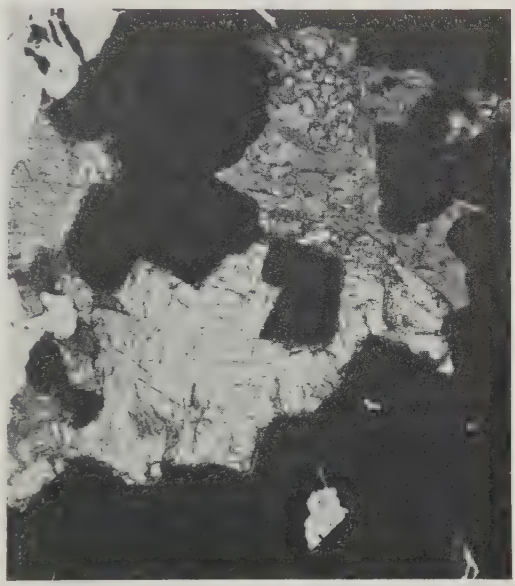


Fig. 9. Skarn iron ore, × 17 1/2, ord. light. Magnetite, scapolite and some hornblende. Alvelandet, Tromøy.

The coccolite—kolophonite skarn was formed by metasomatic processes in the limestones in connection with the intrusion of the arendalites. The ore deposits always occur in close connection with these rocks and are never found at a distance from them. The mineral composition indicates an infusion of FeO, Fe_2O_8 ane MgO into the limestones. The analyses of the arendalites seem to verify this assumption, for their norms show an excess of the oxides mentioned.

The skarn protected the more central parts of the limestones against further metasomatic changes and much of the material in the minerals here met with (diopside, tremolite etc.), is derived from impurities in the limestones.

In this connection the mineral paragenesis found in the Løddesøl-limestone is of interest. Olivine, diopside, tremolite, calcite occur together and indicate normal contact metamorphic products of dolomites. With "normal contact metamorphism" I do not mean contact metamorphism in the usual sense. It is not an ascending magma which has caused the metamorphism, and we cannot here distinguish between an outer and inner contact zone, but we must emphasize that the metamorphism has taken place under the large regional foundering of the whole region. Olivine is one of the first minerals formed by the dedolomitisation. As distinct from tremolite and diopside it is usually serpentinized and occurs in the shape of rounded grains in a calcite—matrix. A similar serpentine—calcite skarn I have found in one of the mines also, and possibly we have had dolomites here too.

Regarding the temperatures at which these processes took place, the vesuvianite is of importance. T. F. W. Barth who has studied the deposits of skarn near Kristiansand writes:

"Die Metamorphose weist auf eine Temperatur die eben unterhalb des Stabilitätsfeldes des Vesuvians liegt. Lokal hat sogar die Temperatur, aber nur während ganz kurzer Zeit, den Bildungsbereich des Vesuvians überschritten." He thinks that the metamorphism has occurred below 500° C.

At the Arendal deposits the temperature also seems only locally, and for a short time, to have reached the stability field of vesuvianite. As mentioned, I have observed this mineral only at Nøddebro and it is difficult to tell whether or not it was ever formed at any of the other deposits. It may have disappeared or the chemical environment may have been unsuitable for its formation.

The ore was formed later and in connection with the intrusion of the granite dikes. It is a fact that several of the granites and pegmatites have a high percentage of magnetite and in the more northern parts of the Arendal district we find relatively large deposits of iron ore in the granite, viz: Lyngrot and Solberg in Holt, described as magmatic by J. H. L. Vogt.

The most common minerals that occur in the ore are diopside, calcite, scapolite, and apatite. Diopside may have formed in various ways, either by a normal contact metamorphism of the impure limestone, or, secondarily, from the coccolite-kolophonite skarn. If the iron of these minerals was removed by leaching, and recrystallized as magnetite, then the garnets would partly change to other minerals or other compositions and the pyroxene would probably become more diopsidic. N. H. Magnusson describes such a reaction from a Swedish locality (1929). The last-mentioned process is theoretically quite interesting but certainly of small importance. Diopside occurs as a typical contact mineral. The opposite reaction seems to be more probable, for magnetite seldom occurs in connection with the coccolite—kolophonite skarn. The formation of garnet and hedenbergite can be expressed in terms of the following reaction (N. H. Magnusson):

$$Fe_3O_4 + 4\ CaCO_3 + 5\ SiO_2 = Ca_3\ Fe_2\ Si_3O_{12} + Ca\ Fe\ Si_2O_6 + 4\ Co_2 .$$

In regard to the genesis of the iron ore, scapolite, tourmaline, apatite etc, indicate that pneumatolytic agencies, derived from the granitic solutions, were instrumental in the formation of the ore, thus in their mode of origin resembling that of the contact metasomatic deposits of the Oslo region (V. M. Goldschmidt 1912). The granitic solutions rich in water and other volatile constituents permeated the skarns and the other strongly folded rocks of the ore deposits wherever they found suitable openings inducing replacements of the existing minerals by aquaeous minerals, such as amphibole, epidote, mica etc. Fractures and joints in the neighbourhood of the granitic dikes are usually filled with amphibole, epidote etc. The pyroxene may be replaced by hornblende, the uralite still containing a core of pyroxene. The epidotization in places proceeded so far that epidote is among the most abundant of the skarn minerals.

The minerals of the basic effusives, sills and dikes, were also changed and gave rise to schists or masses of skarn of hornblende and mica. The plagioclase has in places disappeared but forms often a saussieritic mass between crystals of hornblende, epidote and mica.

Among the youngest minerals encountered in the deposits are pyrite and chalkopyrite which fill small cavities in the skarn, and were formed at low temperature by hydrothermal processes.

3. Geological Description.

The longest of the skarn zones is drawn in Fig. 14. Almost continuously it can be followed from the Grimstad granite to Solberg, only interrupted where no skarn is found, between Nøddebro and Seldal and between Klodeborg and Solberg. The strongly folded rocks of the oldest complex can be seen all the way.

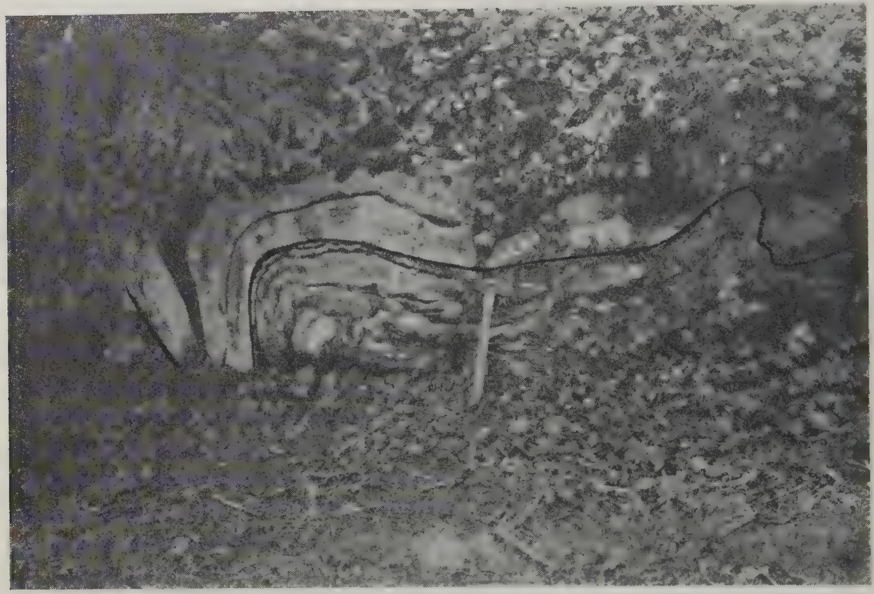


Fig. 10. Gneissbanded limestone from Klodeborg.

The zone is approximately straight, the breadth varies. It passes by transitions into the country rocks. On the map I have drawn rather arbitrarily a border line to indicate the zone, which is, or has been, of economic importance, as a demarcation of the area where skarn, mines, pits or other workings, or ore, commonly are found. All such workings from the mining periods are marked on the map, and it is seen that all are situated within the skarn zones.

The limestone is commonly replaced by skarn silicates and ore, but in some places, viz: Ranneklev, Nøddebro, and the mine of Klodeborg the limestone is partly preserved.

The limestone is frequently met with in vein-like masses, probably formed from circulating solutions, which in some places have dissolved the sedimentary limestone and redeposited calcite in fissures or crevices with "eruptive-like" aspect. In certain parts, as in the north-western part of the Klodeborg area, the limestone probably lies rather near its original place. Fig. 10, from the Klodeborg area displays some layers of gneiss-banded limestone and fig. 11 the same layers in the opposite direction at a distance of ca. 25 meters. The

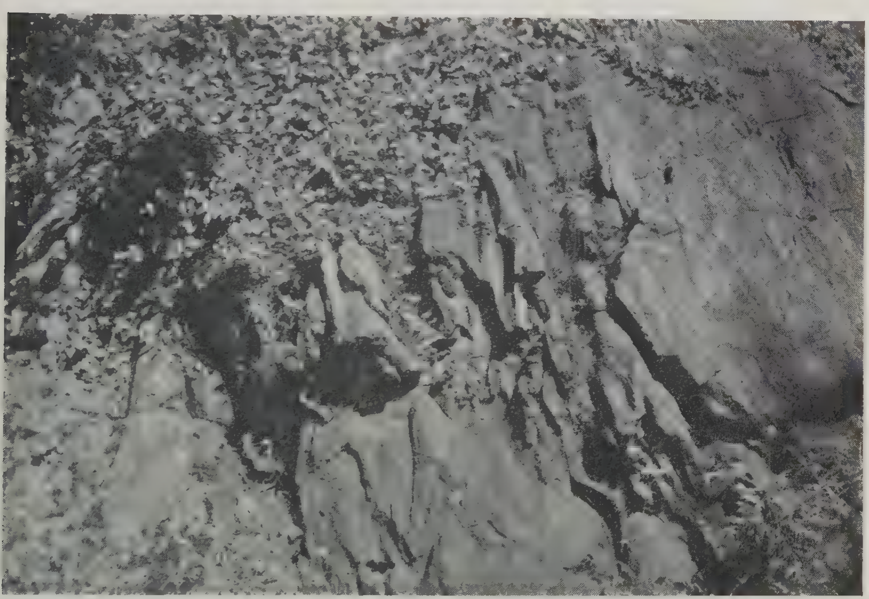


Fig. 11. Gneissbanded limestone from Klodeborg.

folding axis dips ca. 45° towards SW and on a horizontal plane the bands therefore will form wavy lines normally to the projection of the folding axis, as I have shown in fig. 3.

In the south-eastern part of the Klodeborg area there are large isoclinal folds with the folding plane striking NE—SW and dipping 60—70° SE. The mines are considerably larger in this part of the area and the layers of limestone have here in a higher degree been metamorphosized to skarn than have the flat lying beds in the northern part. Probably the ascending solutions could better find their way parallel to the foliation planes of the rocks than normal to the planes. The fact that the limestone at elevated temperature and under sufficient differential stress yields in a quasi-plastic fashion (page 78) has in the mining district been of importance and has influenced the size of the various ore deposits. Harker (1932) writes: "When a bed of limestone is involved in a system of closely oppressed folds, it may become entirely dissolved away in the middle limbs of the folds, the material being transferred to the crests and troughs which were places of relative relief."

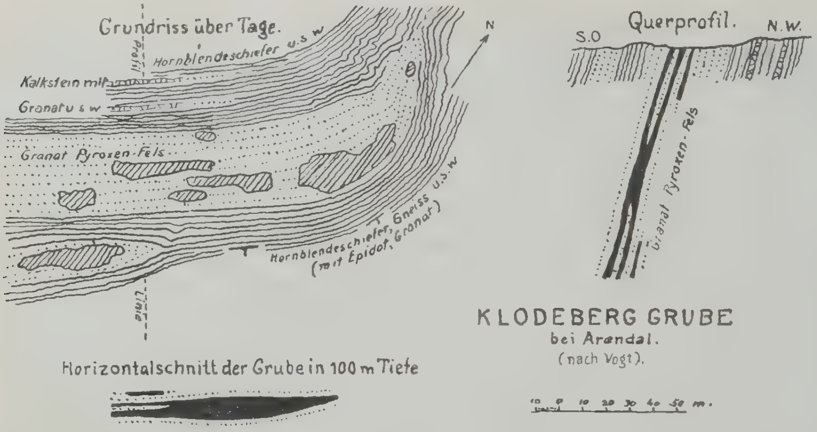


Fig. 12.

In this way the limestone may be squeezed out to lenses or rulers which have their longest axis parallel to the stress direction of the country rocks, just as in the case of many lenses of ore. J. H. L. Vogt writes about the mines of Klodeborg as follows: "The mine dips about 65° SE and besides shows a pronounced rake of about 23° towards SW." The direction of the axis of the ore coincides with the linear stress of the country rock. (Fig. 12.)

As a rule, the mines have their longitudinal direction towards NE—SW, but occasionally mines are found which are elongated in the direction NW—SE and dipping towards SW and these mines are connected with synclines and anticlines in a folding system with the axis dipping towards SW (Mikkelsberg west of Seldal, several of the Lærestveid mines etc.).

Almost without exception the mines in the whole district arrange themselves along several parallel lines or zones, the spacing between the lines is a few meters, but varies somewhat with the size of the folds. This structure is particularly well brought out on the map of Klodeborg and Langsev, fig. 12 and 15. Occasionally the folds may be followed from one of the zones mentioned to another.

The mines of Solberg, Torbjørnsbo and Langsev belong to the same large zone, but they are all completely surrounded by arendalite rocks. Th. Kjerulf and T. Dahll undertook a very detailed mapping of the ore-bearing region. The map gives an excellent picture of the structure of the mining districts and may, with a few corrections, very well be used to-day. The authors especially emphasize the complete bending of the schists around the mines. Langsev is terminated towards NE and Torbjørnsbo towards SW. The two fields are mutually somewhat displaced, they seem to be quite separated from each other by the arendalite rocks. They probably represent one large fragment of the old complex which, during the uprise of the magma, cracked in two.

The rather strongly inclined strata along the borders are mainly caused by the mutual movement and friction between the magma and the old complex. The foliation is always conformable with that of the arendalites and concordant with the margins.

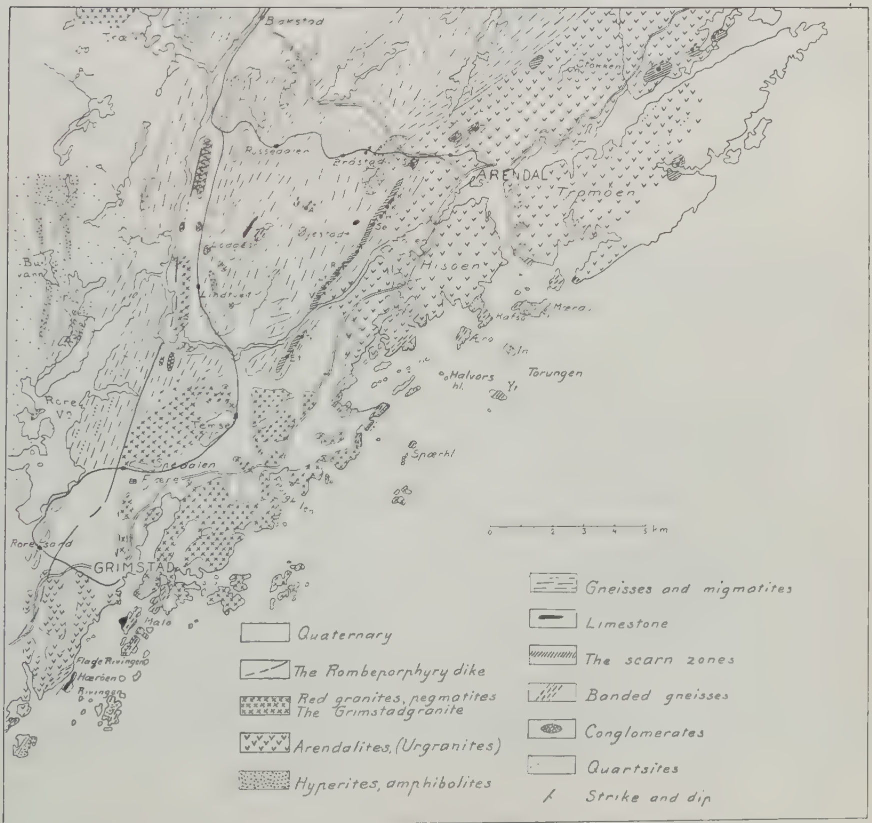
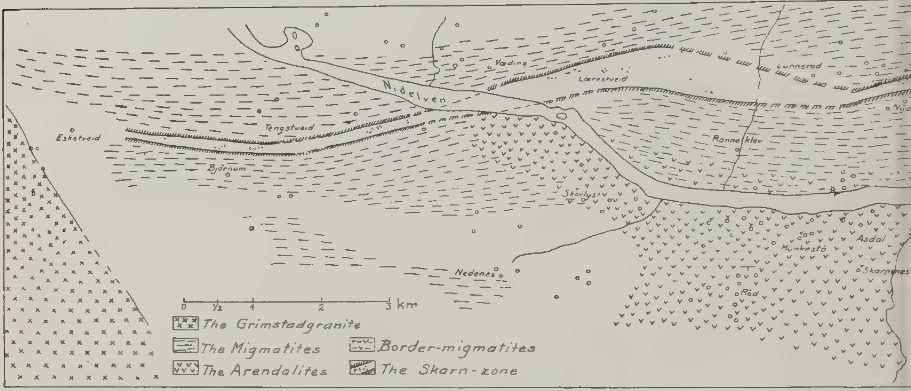


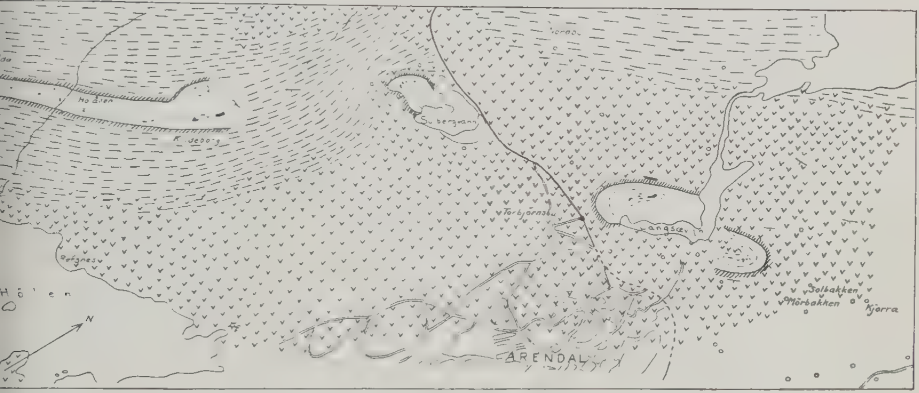
Fig. 13.

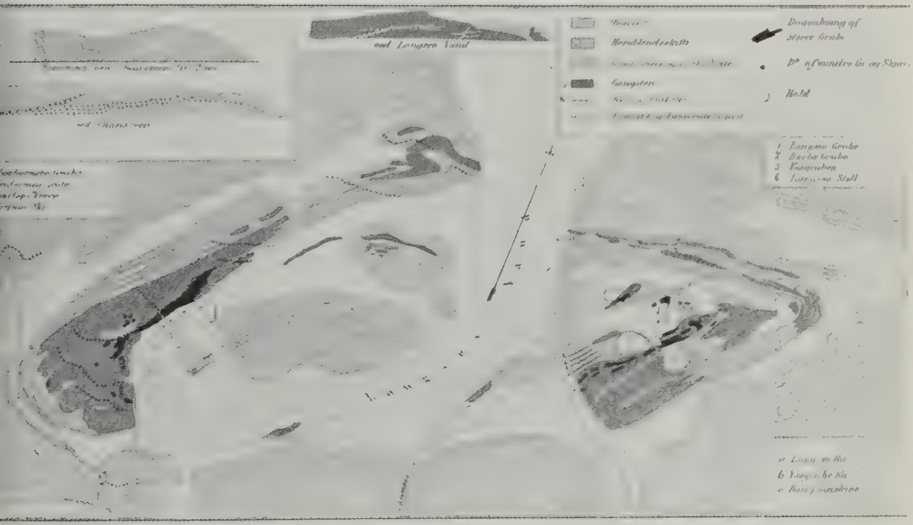
The Aren


Esketveid
Tengstveid
Bjørnum
Nidelven
Væding
Lærestveid
Lunnerød
Rønneklev
Skövlys
Asdal
Munkestö
Skarpnes
Nedenes
Rød
0 ½ 1 2 3 km
The Grimstadgranite
The Migmatites
The Arendalites
Border-migmatites
The Skarn-zone

LANGSEV THORBJÖRNSBO samt SOLBERG ERTSFELDT
Profil fra NV til SO forbi Langsev Stoll.
Solberg Gruber
Bude Gruber

strict.


Hoåsen
Kjeborg
Subergvann
Torbjörnsbu
Langsæv
Refsnes
Hölen
N
Solbakken
Mörbakken
Kjerra
ARENDAL


Hornblendeskifer
Gangsten
Hald
1 Langsæv Grube
2
3 Vaagruben
4

It can be seen from the map of Kjerulf and Dahll that, like the schists, the dikes of granite bend around the mines. This picture is, however, not quite correct, for just at the bend the intrusive dikes are replaced by pegmatitic and granitic gneisses, but otherwise they usually follow the foliation and thus, in the same way as the schists, tend to bend together with them.

The Solberg area (see Fig. 14 and 15) is situated rather near the border between the arendalites and the old complex. Between Klodeborg and Solberg one sees the folding axis, which at Klodeborg dips steeply towards SW, lying rather flat, in places horizontally. Near the border of the arendalite rocks the schist layers are bent strongly upwards, in the border zone itself the layers are reversed with steep dips in the opposite direction. The Solberg area is completely detached from the old complex being entirely surrounded by arendalite. Towards SW the igneous rock is, however, so strongly mixed with material from the old complex that it perhaps ought to be considered as a border migmatite.

Probably the magma was not introduced by a single act of injection. It was probably slowly eating its way into the old complex, the material of which partly became assimilated.

Summary.

Rocks of sedimentary origin and probably also of effusive origin are common among the oldest rocks in the Bamble formation. The wide distribution of quartzites in the north-western part of the Arendal district is decidedly in favour of a sedimentary origin, and the main limestone-skarn zone which can ee followed for several kilometers in the direction of the strike, should, I suppose, by similarly interpreted.

Thus far no decisive proof of the existence of effusive origin has been found, but the structure of the banded gneisses indicates a supracrustal origin of these rocks.

The strongly folded rocks of the old complex were later invaded by hyperites, arendalites and granites. The name arendalite has been introduced for a new rock series ranging in composition from norites and hypersthene-diorites to charnockites. The types are related both in space and time and seem to form a batholith which is cut rather near the roof.

The skarn ore deposits lie in the skarn-limestone zones and are of contact metasomatic origin.

The correlation between the Bamble formation and other Archean districts is as yet very uncertain. Several Scandinavian geologists have tried to compare it with the Archean in Sweden and especially with the leptite formation of central Sweden. The present investigation has demonstrated a great similarity in the geology of the two districts. In both districts the oldest rocks are of supra-crustal origin, the limestones appear chiefly in connection with effusives, and the urgranites make up highly differentiated series. The post orogenic eruptions seem also to resemble those of the Bamble formation. Common leptites are scarce in the Bamble formation; usually they have been metamorphosed to leptite gneisses.

The charnockites often show a close resemblance to the charnockites of the Egersund districts and there may exist a connection between the two districts. In the Arendal district we have, however, never found bigger masses of anorthosites which are so common in the Egersund district.

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EXPLANATION OF PLATES

Pl. I

Fig. 1. Folds in banded gneiss. Spacing of limbs 5—6 m. Folding axes dipping 10—50° SW. Morvigen, Landvig.

» 2. From the migmatitezone of the banded gneiss. Østre Spærhl., Øyestad.

Pl. II

Fig. 3. Parallel aplitic dikes transversing the acid gneiss. Indre Torungen.

» 4. Microphoto of Hyperite, Tromøy. × 17 1/2.

P = pigeonite.
Pl = plagioclase.
s = magnetite-hypersthene-symplectite.
hy = hypersthene.
H = hornblende.
G = garnet.

Pl. III

Fig. 5. Microphoto of hornblende norite. × 17 1/2, ord. light. NE of Langsev ore district.

Pl = plagioclase.
H = hornblende.
hy = hypersthene.
m = magnetite.
a = apatite.

» 6. Hornblende replacing hypersthene (uralite). × 63, ord. light.

Pl. IV

Fig. 7. Microperthite in charnockite. × 60, nic. crossed.

» 8. Myrmekite in charnockite. × 60, nic. crossed. Klåholmen.

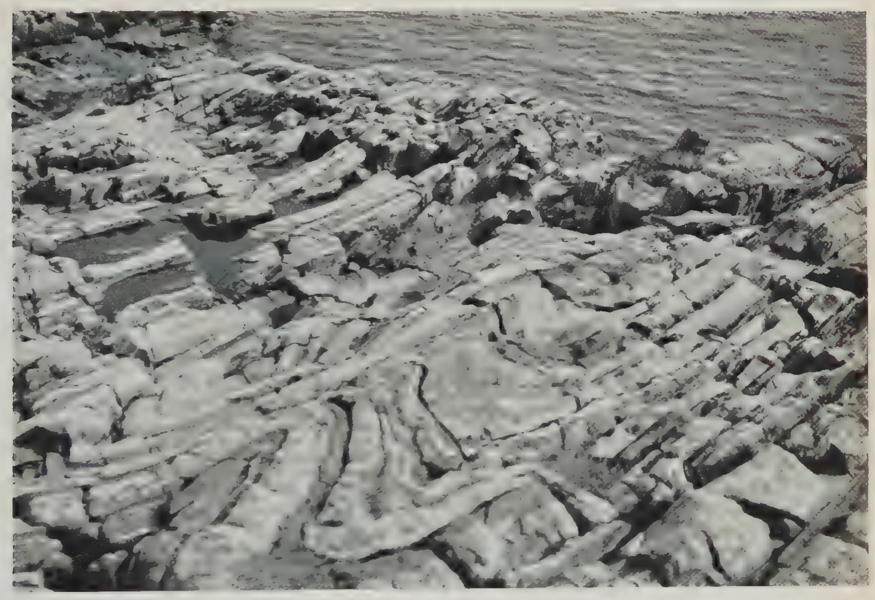


Fig. 1

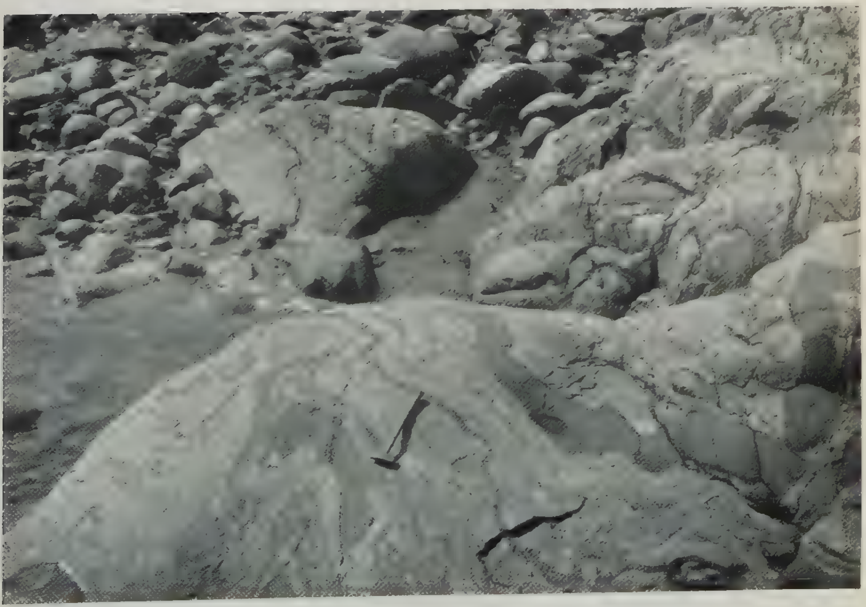


Fig. 2

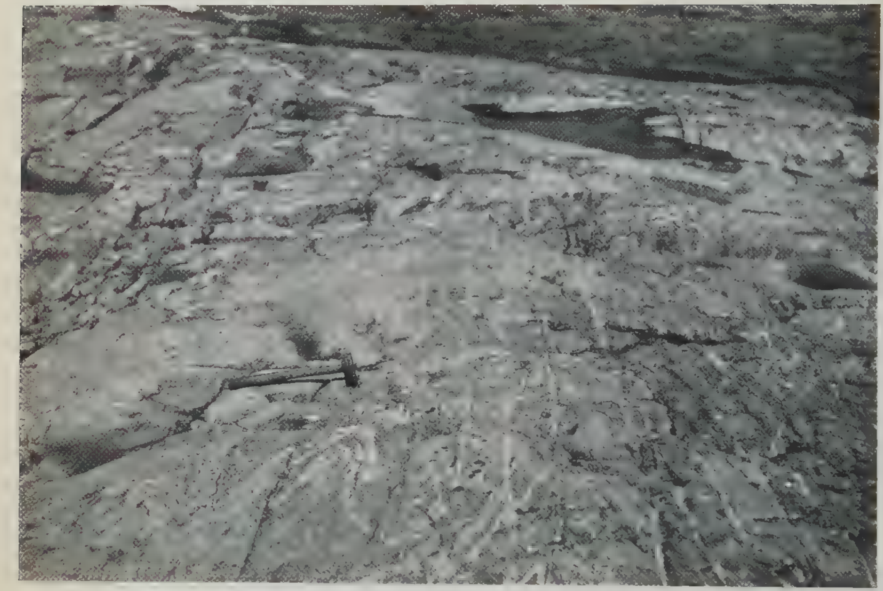
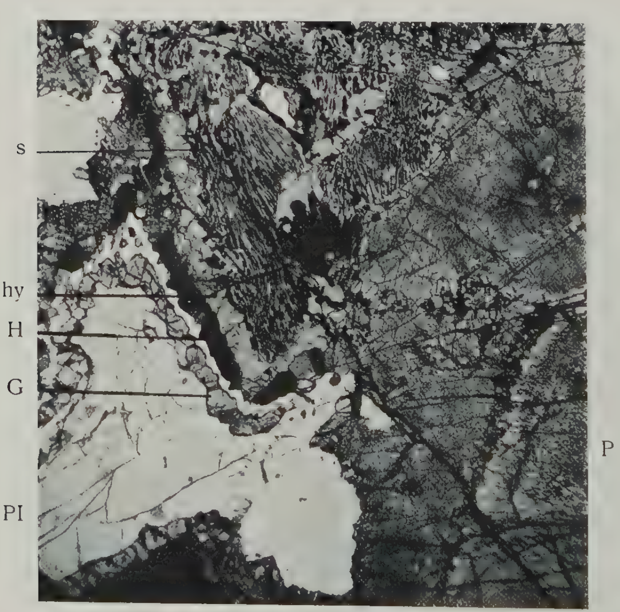


Fig. 3



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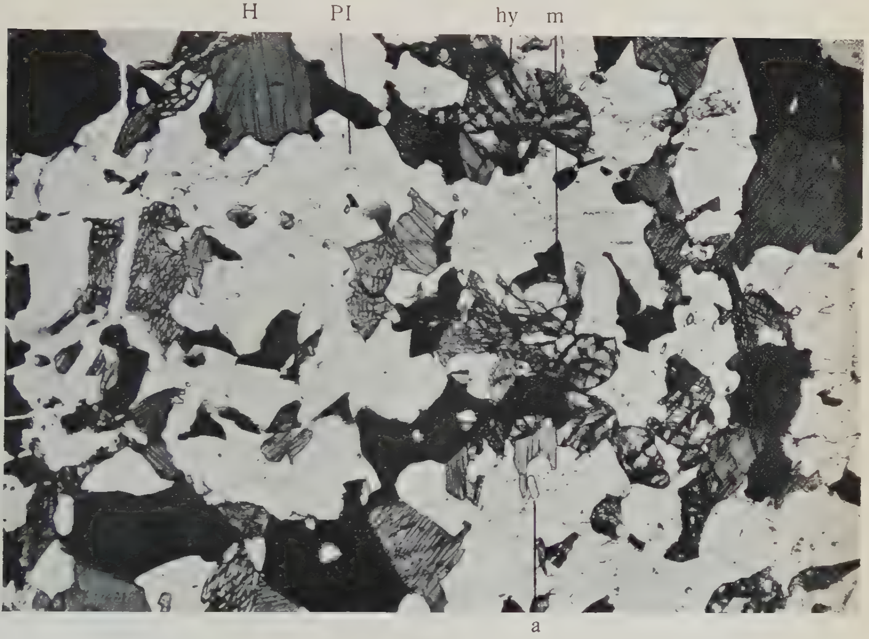


Fig. 5

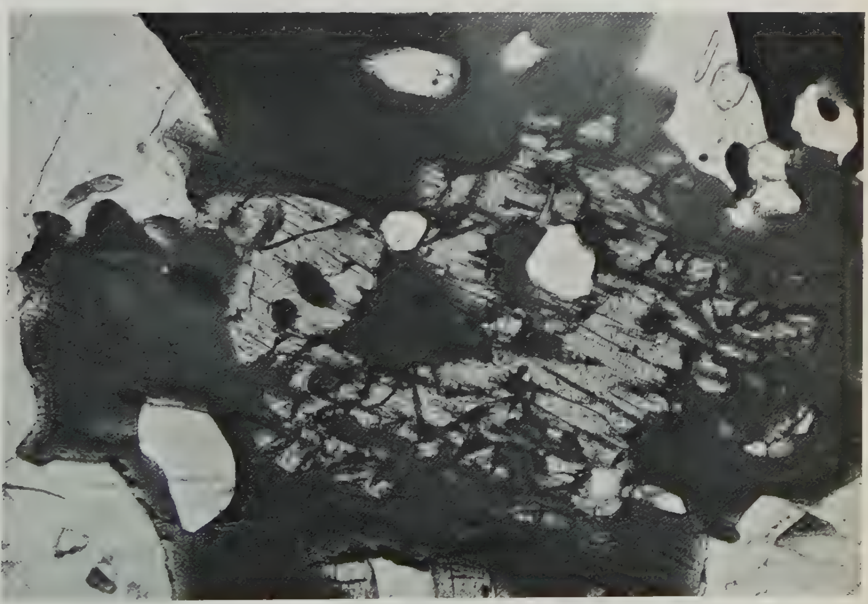


Fig. 6

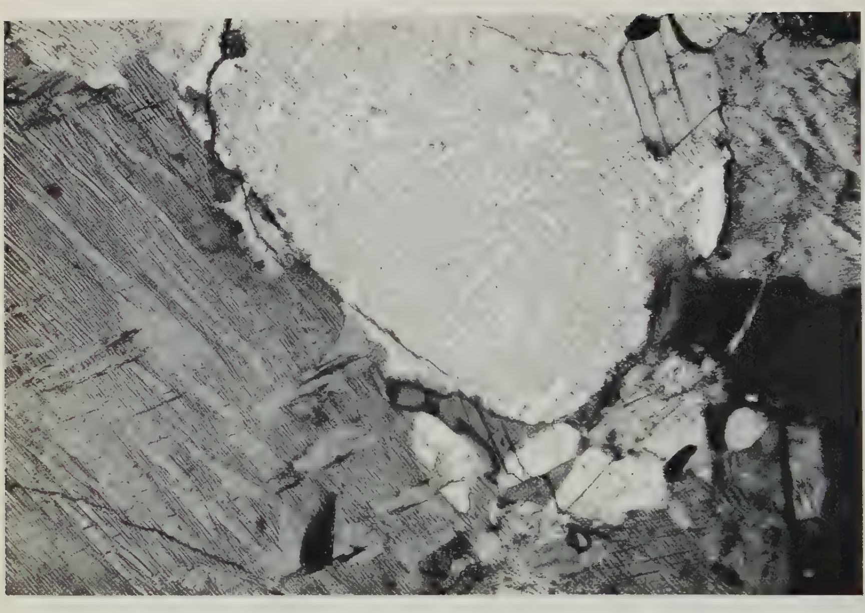


Fig. 7

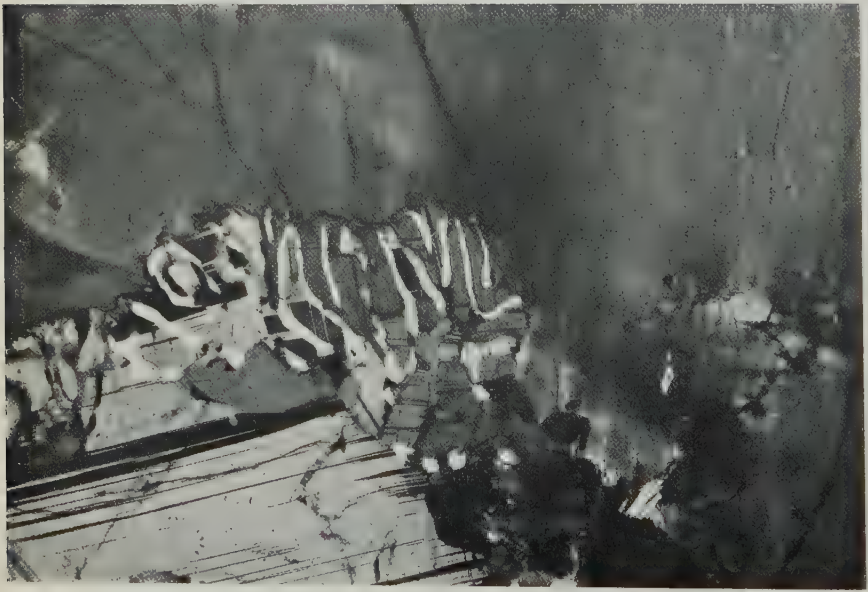


Fig. 8

M. s. rec. Nov. 30, 1939.

EARLY DESCRIPTIONS OF NORWEGIAN TRILOBITES

THE TYPE SPECIMENS OF C. BOECK, M. SARS AND M. ESMARK

BY

LEIF STØRMER

WITH 3 PLATES AND 4 FIGURES IN THE TEXT

Abstract: The main scope of the present paper has been to illustrate a number of trilobite species described by Norwegian authors more than one hundred years ago. The early descriptions are generally very brief and incomplete and are rarely accompanied by good illustrations. It has therefore been difficult to distinguish the specific characters of many important trilobite species occurring in the Cambro-Silurian strata of Scandinavia. In the old collections of the Paleontological Museum it has, however, been possible to find most of the original specimens and from among those the types have been selected. The types are presented in untouched photographs and the reprinted original descriptions are commented upon. A brief historical review of the early paleontological studies in Norway is also given.

CONTENTS

Introduction 113
The Type Material 115
Historical Review of Early Trilobite Studies in Norway 116
Discussion of Publications 122
List of Norwegian Trilobite Species and Varities described by Esmark, Sars, Boeck and Angelin 148
Bibliography 150

Introduction.

New investigation and revision of previous studies of fossil faunas have more and more emphasized the necessity of distinguishing the type specimens on which the first specific descriptions were based. The most common and important species were generally established in early days when only brief descriptions were demanded. Illustrations, if present, are usually very incomplete and frequently less successful reconstructions were preferred to accurate drawings of the type specimens.

For these reasons it has in many cases been very difficult to establish the different species, and the incomplete knowledge of the types has caused considerable confusion in the taxonomy. At the same time several early species have been neglected on account of inadequate description. Only an establishment of the type specimens, or specimens, in the original collections may later rehabilitate discarded or neglected species and varieties.

Fossil remains of trilobites in the Cambro-Silurian beds of the Oslo Region early attracted the attention of students in the natural sciences. Collections and detailed studies of Norwegian forms led to the descriptions of several new species including a larger number of important forms serving as guide fossils for the Lower Paleozoic strata of Scandinavia. The old descriptions are very brief and usually without illustrations, and the species have therefore been difficult to establish unless later authors have extended and completed the description from studies of the original material.

The Paleontological Museum of the University in Oslo has on several occasions been consulted as to the existence of the old types. As shown below, it has become possible to trace a large number of cotypes of the species described. In order to distinguish and illustrate the trilobite species described by the early Norwegian authors, I have found it appropriate to figure (in untouched photographs) and briefly comment upon the more important types. Since the early descriptions are found in publications not easily accessible, the descriptions of the new species and varieties are cited. It is to be hoped that this additional knowledge of our early described Ordovician trilobites may be useful to Scandinavian stratigraphy and stimulate the further research of the insufficiently known faunas of the Ordovician beds of Norway.

I wish to express my thanks to the Curator of the Paleontological Museum, Dr. A. Heintz, for the interest he has shown in the present work. Thanks are also due to Dr. T. Strand who has gathered together most of the specimens belonging to the old collections. Miss Lily Monsen has skilfully assisted in making the photographs which are published untouched.

The Type Material.

The old fossil collection of the "Mineralkabinet" of the University in Oslo now belongs to the Paleontological Museum. The collection comprises those of Sars, Boeck and Esmark (J. and M. Esmark) and thus includes the types applied in the early descriptions. The original specimens are marked either with a small rectangular white label without number (Sars?), or a red rhombic label with a number written on it as shown on pl. 3, fig. 3. The specimens with the small red labels on them have also a loose, written label bearing the same number as the red label, the name of the species, the page on which it was described in the paper by Boeck (1838), and the locality. In certain cases the label signifies that the specimen has been used to make the illustrations in Sars' or Esmark's papers.

The specimens of the old collections served as cotypes (when no type specimen is selected the specimens of the original material are called cotypes). Concerning the designation of types I have found it useful to separate strictly the types (holotype, lectotype and neotype) and the typoids (paratypoid and hypotypoid) as suggested recently by Richter (1935). For each species or variety a lectotype is chosen among the cotypes. When no specimens from the original collection has been found, a new specimen is established as neotype when sufficient reasons are present to justify this. Each of the other specimens figured in the original description is a paratypoid; one figured in a later paper is to be regarded as a hypotypoid.

Types have been established for a larger number of the described species and varieties. In certain cases it has been impossible to trace any of the original specimens and if no further descriptions have confirmed the validity of the species it has had to be discarded. Not all the lectotypes are figured in the present paper. When a species is well described and illustrated in later papers I have found it of minor importance to present new illustrations.

The main purpose of the present paper has been to illustrate the types. Only remarks are added to the reprinted original descriptions. New and detailed descriptions of the species ought to be postponed to future treatments of the various trilobite groups. Likewise complete synonym lists have to be made out in connection with special studies, but as far as possible I have tried to use the correct or latest generic names. At the end of the present paper a list is given of the

Norwegian species described by the early authors. The species of the Swedish author Angelin are also included, but although some of his types might be found in the collection of the Paleontological Museum in Oslo, his types can hardly be distinguished without a detailed examination also of the Swedish collections.

Historical Review of the Early Trilobite Studies in Norway.

Norwegian fossils were primarily described by foreign scientists, but already in the first part of the late century remarkable trilobite studies were carried out by Norwegian students in the natural sciences.

Already the Danish scientist Brünnich (1781) describes and figures under the name *Trilobus dilatatus* the trilobite *Ogygiocaris dilatata* (Brünnich). The species was founded on specimens which Brünnich had received from the Fossum Ironworks near Skien in Norway. Probably the specimens had been collected in the same region which therefore might include the type locality of this important species.

In 1826 v. Schlotheim in Germany describes *Illænus esmarkii* Schlotheim from Norwegian specimens presented to him by Professor Jens Esmark in Oslo.

The Norwegian trilobite studies are linked to the names of Boeck, Esmark and Sars and brief account of their studies is attempted below.

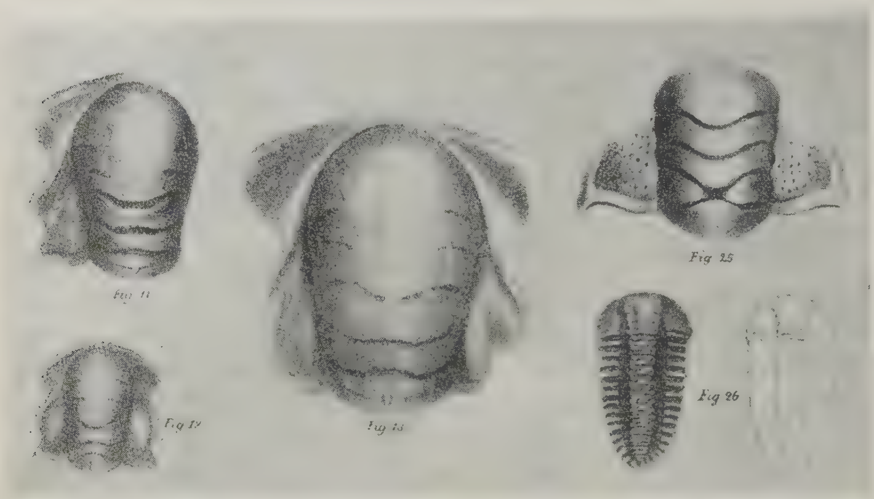
Christian Peter Bianco Boeck (1798—1877) was professor in physiology, comparative anatomy and veterinary science at the university in Oslo. He was born in Kongsberg, the town with the silver mine and the seminary of metallurgy. He early developed a keen interest in natural sciences. Boeck lectured a short while (1819) in natural science and physics at the military school in Christiania (Oslo) and after he had passed his medical examinations he went abroad to study veterinary science. On his journey he was accompanied by his intimate friends Professor B. M. Keilhau and Niels Henrik Abel, the famous mathematician. Abel's letters to Boeck were published by Holst, Størmer and Sylow (1902). Already in 1820 Boeck travelled with Keilhau in Central Norway where they "discovered" the high mountains and lakes of Jotunheimen, and later (1836) they went together along the Norwegian coast from Oslo to Trondheim to study a possible upheaval of the land. On these occasions Boeck had the very best opportunity of getting a first hand knowledge of the various fields of geology. On several journeys abroad, sometimes accompanied by Keilhau, Boeck visited many scientific institutions and got in touch with leading geologists and biologists, i. e. the paleontologist A. Brogniart as mentioned in Abel's letters (l. c.).

Of great importance to his biological studies was the collaboration with Pastor M. Sars, one of the most outstanding zoologists of his time. With his knowledge in physiology and medical science, Boeck dominated a very broad field in biology. His numerous publications, also including botany, cover very different subjects and show well his general outlook in natural sciences.

It deserves to be pointed out that with his broad and detailed knowledge of natural science and of foreign scientific research, Chr. Boeck has been of great importance to the development of natural science in Norway. In the early days of the University in Oslo he was in many ways the central figure who stimulated and connected the new and far-reaching research of men such as Abel, Sars, Keilhau and others. Boeck joined in founding "Den physiographiske Forening" (later the Academy of Science in Oslo) and "Lægeforeningen i Kristiania" (later the Medical Society), and he was also for many years the editor of the periodical "Magazin for Naturvidenskaberne".

The paleontological studies of Boeck evidently began in his early student days. In the Oslo Region he collected numerous fossils, especially trilobites, and he fully realized the general importance of these as very old biological documents. Travels abroad gave him the opportunity of studying foreign collections and this was of great help in his future studies of Norwegian fossils.

In his first paper on trilobites Boeck (1827) presents a study of the group and deals with a number of foreign species which he personally had examined in Middle European collections. In addition to previously known forms he describes and figures several new species: *Trilobites minor*, *Tr. gracilis*, *Tr. zippey*, *Tr. sternbergi*, and *Tr. major*. The last name is not actually established in the paper, but under the description of *Tr. minor* a larger form is mentioned and the name *Tr. major* given in later papers evidently alludes to this. According to Barrande (1852, p. 22), Sternberg (1833) in discussing



Text-fig. 1. Bohemian trilobites figured and described by Boeck 1827. Fig. *12*=*Paradoxides spinosus* (Boeck MS) var. *minor* (Boeck), fig. *13*, *14*=*Paradoxides spinosus* (Boeck MS) var. *major* (Boeck), fig. *25*=*Cheirurus sternbergi* (Boeck), fig. *26*=*Placoparia zippei* (Boeck). Reproduced in 3/4×.

Boeck's paper uses the name *major*, but instead of quoting it as the name of species, he gives both *major* and *minor* as varieties of *Trilobites spinosus* Boeck. The explanation of this according to Barrande (l. c., p. 370) is that Boeck in sending his paper to Sternberg had added on the plate, a written note altering the names in this way. Sternberg discarded *Trilobites gracilis* which he found to be a young stage of a previously known species (*Paradoxides*). As shown by Barrande (1852, 1872), the following of Boeck's species and varieties have to be maintained: *Paradoxides spinosus* (Boeck MS) var. *minor* (Boeck), *P. s.* (B. MS) var. *major* (Boeck MS), *Placoparia zippei* (Boeck) and *Cheirurus sternbergi* (Boeck). Fig. 1 shows Boeck's original illustrations of these species and varieties which form an important part of the Bohemian fossil fauna.

In the same paper Boeck also discusses the zoological position of the trilobites and indicates that the resemblance to crustaceans might be due to convergence and not necessarily signifies a closer relationship.

In these years Boeck made extensive collections of Norwegian trilobites. He was accompanied on his excursions by M. Sars (see below) and they planned to cooperate in describing the Norwegian trilobite species. The cooperation was, however, interrupted when Sars had to move to Bergen and Boeck went abroad. But a paper by Sars and Boeck was ready in manuscript and was read by Boeck before the scientific society "Den physiographiske Forening", at the February meeting in 1829. The paper "Om de i Norge forekommende Trilobiter" was not published, but the title and a note saying that the paper was accompanied by illustrations, is given in the brief reports of the meetings printed in "Magazin for Naturvidenskaberne" (Sars and Boeck 1833). In vain have I searched for the manuscript among the documents of the "Physiographiske Forening" preserved in the University Library. Nor has it been possible to trace the original journal of the society which is said to be found at the secretariat of the University. In a later paper (Boeck 1838), the species dealt with in the manuscript paper are referred to as Boeck et Sars Mscr.

In 1838 appeared Boeck's monograph on Norwegian trilobite species. In Keilhau's memoir: "Gaea Norvegica" Boeck describes about fifty species of which a large number were new to science or were given manuscript names by Sars and Boeck. Unfortunately, the descriptions of the species are very brief and often incomplete and lack illustrations. The monograph has none the less been of great importance especially to the study of Scandinavian trilobites. The paper is discussed in a later chapter and the descriptions of the new forms are cited (p. 135).

Boeck (1841) read a paper on trilobites at a meeting of the "Skandinaviske Naturforskermøte" in Copenhagen in 1840. According to the brief printed account of the lecture, he discussed the classification of trilobite genera. Concerning the nature of the trilobites he followed Wahlenberg in placing them near *Limulus*. Boeck (1851) also published a paper on graptolites.

Hans Morten Thrane Esmark (1801—1882) was pastor at Brevig in the centre of the Skien—Langesund district which besides its rare minerals also has rich fossil localities. He was the son of Jens Esmark, professor in metallurgy in Oslo (Christiania). Through his father he early became interested in geology and in the Langesund district he had the best opportunities of collecting and studying the minerals and Cambro-Silurian fossils of this region. Esmark discovered and described several new minerals and in 1833 he published a short paper on trilobites. The note contains descriptions of several new species as shown on p. 122. The illustrations (fig. 2) have been useful in establishing the types.

Michael Sars (1805—1869), a clergyman and later professor in Zoology at the University, is well-known as one of the most eminent zoologists of his time. Sars has also presented valuable contributions to the knowledge of Norwegian fossils and together with Boeck he founded the paleontological science in Norway.

Already in 1823, when he became a student at the University in Oslo (Christiania), he had the testimony of his school-teacher saying that Sars was particularily interested in animals and fossils. At the university, Professor Jens Esmark highly stimulated his geological-paleontological interests. Sars made numerous fossil excursions in the neighbourhood and in the city itself. He writes in his autobiographical notes translated from Halvorsen (1901) and Nordgaard (1918): "Daily I made excursions in order to collect fossils, often accompanied by my friend and room-mate, my later brother-in-law Welhaven [the poet], whom I had inspired a keen interest for these at that time so little known and problematic animals of the world of the past. Often we went even during the hardest winter time over the fjord-ice to Ladegaardsøen [Bygdøy], one of the richest localities, and after having filled all our pockets with trilobites and other fossils, we still brought as many limestone lenses we could carry, for later at home in our room leisurely to knock out what they might contain inside, an enterprise which not always passed without a protest from our host who meant that he had not let the room to us as a stone-cutter's workshop. We thus made fairly considerable collections of fossils, thereamong several new, which I had in mind later to work out and publish."

As mentioned above, Sars in collaboration with Boeck wrote a paper on Norwegian trilobites, but the paper only appeared in manuscript and on account of Boeck's travel abroad and Sars' moving to Bergen, the future collaboration was interrupted. In Bergen Sars got little opportunity to study Paleozoic fossils and his zoological studies from now on took most of his spare time.

In 1835 he published, however, an important paper: "Über einige neue unvollständig bekannte Trilobiten." As shown below (p. 125) the paper gives valuable descriptions and good illustrations of several of our most common Ordovician Trilobites. The clear and detailed descriptions, and the thorough discussion of the hypostomal structures in trilobites, are quite unusual for his time.

When Keilhau and Boeck in 1836 visited Sars at Florøy, an arrangement was made whereby his fossil collection was transferred to the University and at present it is preserved in the Paleontological Museum.

In later years Sars always maintained his deep interest in fossils. When he returned to Oslo (Christiania) as professor in 1854, he began, in connection with his description of arctic faunas, to study quartenary fossils and his results are published in several important papers, among which: "Om de i Norge forekommende fossile Dyrelevninger fra Kvartærperioden, et bidrag til vor Faunas Historie." (Kristiania 1865) is the most classical.

Norwegian trilobites were also described and mentioned by the well-known Swedish paleontologist N. P. Angelin, and the Norwegian Professor in Geology Th. Kjerulf.

In his monograph "Palæontologia Scandinavica P. I. Crustacea Formationis", Angelin (1851—1878) describes 34 species and varieties of Norwegian trilobites. An index to the monograph is given by Westergård (1910). As may be seen from the list p. 148, 23 species and 2 varieties were new (11 species and 2 varieties described from Norwegian specimens only). In establishing new species he considered to a large extent those founded by Esmark, Sars and Boeck.

To be mentioned, there remains the trilobite lists given by Kjerulf (1865) in his guide of the Oslo Region. One new species is figured without description: *Illænus glaber* (l. c. p. 14, fig. 28). It is evidently identical with *Illænus Linnarssoni* Holm (Holm 1882, 1886). Holm did not maintain Kjerulf's name on account of the lack of description and the fact that he was unable to find the type specimen in the Norwegian collections. The museum collection has several specimens which are labelled *Illænus glaber*, but they are from Slependa, Asker, not from Bygdøy, and it seems correct to discard Kjerulf's species and replace it with *Illænus linnarssoni* Holm.

In the present discussion I have not included the descriptions of the Lower Cambrian trilobites from Tømten, Ringsaker. Those fossils were discovered by the Swedish paleontologists J. G. O. Linnarsson in 1870 and the papers dealing with this find thus belong to a later period and might be studied in the account given by Kiær (1916).

Discussion of Publications.

Since the old trilobite papers are not easily accessible, the original text is cited (in petit) to a great extent in the following discussion. All descriptions of new species are given in extenso. Only brief remarks are added to the original descriptions. As far as possible the right generic name is given, but complete synonym lists have not been worked out, such a study demands not only an extensive study of the literature, but also examinations of specimens in foreign collections.

1833. M. T. Esmark: "Om nogle nye Arter Trilobiter." (On some new species of trilobites.) The illustrations are reproduced in text-fig. 2. Esmark describes five new species of which one can hardly be maintained.

Proetus asellus (Esmark) — *Trilobites asellus* Esmark.

Text-fig. 2a, pl. 1, fig. 1.

"Trilobites Asellus — capite semicirculari, marginato: glabella elevatiuscula, antice rotundata, lateribus parallelis; oculis ad glabellam sitis; angulis capitis acutis; — segmentis trunci decem; — pygidio sulcis tribus vel quatuor ad marginem ovanescentibus.

Efter et ufuldstændigt Exemplar, fundet i sort Kiselkalk ved Trosvigen i Nærheden av Brevig, er Beskrivelsen og Afbildningen Tavl. VII Fig. 5 i dobbelt Størrelse given."

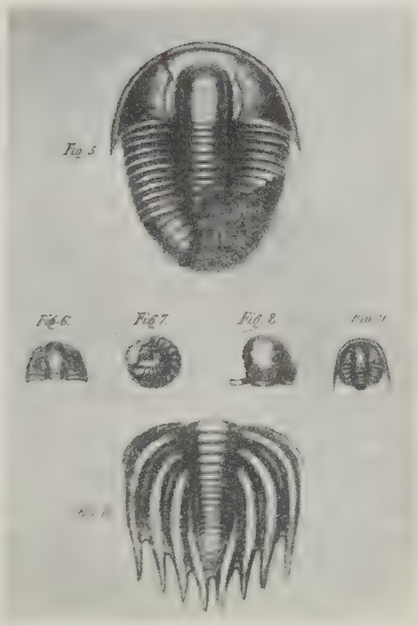
Remarks: According to Esmark's description the species apparently is based on one specimen only. This specimen is found (pl. 1, fig. 1) and the label bearing the name has later also been marked as "original". The small specimen is preserved in pyrrhotite in a hard, black metamorphic shale from Trosviken, Brevig. The shale evidently is the Trinucleus Shale (4cα) which usually has pyrrhotite fossils in this region.

Lectotype: No. 56442 Pal. Mus. Oslo Coll. (Pl. 1, fig. 1).

2. *Phacops elliptifrons* (Esmark) = *Trilobites elliptifrons* Esmark.

Text-fig. 2, 6, 7. Pl. 1, fig. 2—4.

"Trilobites elliptifrons — capite semicirculari: glabella convexa, eliptica, postice coarctata, utrinque nodulo parvo aucta; oculis tuberculatis, granuloso reticulatis; sulco verticali ad angulos capitis continuato; — segmentis trunci duodecim; — sulcis pygidii simplicibus, ad marginem evanescentibus.



Text-fig. 2. Norwegian trilobites figured by Esmark 1833. Fig. 5 = *Proetus asellus* (Esmark) (= *Trilobites asellus* Esmark), fig. *6*, *7* = *Phacops elliptifrons* (Esmark) (= *Trilobites elliptifrons* Esmark), fig. *8* = *Hemisphærocoryphe sphæricus* (Esmark) (= *Trilobites sphæricus* Esmark), fig. *9* = (*Trilobites semilunaris* Esmark), fig. *10* = *Cybele dentata* (Esmark) (= *Trilobites dentatus* Esmark). Reproduced in ³/₄×.

Forekommer paa Malmöekalven i Overgangskalk. Fig. 6, Tav. VII forestiller Hovedskjoldet fra oven, Fig. 7 et fuldstændigt Exemplar fra Siden: Begge Figurer noget forstörrede."

Remarks: Esmark's type specimens are lost and no specimens with old labels are present in the collection in the Museum. The form is, however, very common in the Llandoverian beds (6c) of the Oslo Region and is generally adopted as a valid species (cf. Kummerov 1927 and Whittard 1938, the latter having examined Norwegian species). The type specimens are from the small island Malmøykalven separated from the main island Malmøy by a narrow sound less than 30 m wide. Since Esmark's specimens are lost, a neotype has to be chosen. I propose to choose one of the good specimens from Malmøy, collected and determined by Th. Kjerulf, as a neotype.

Neotype: Nr. 20966 Pal. Mus. Oslo Coll. (Pl. 1, fig. 2—4).

3. *Hemisphærocoryphe sphæricus* (Esmark) = *Trilobites sphæricus* Esmark.

Text-fig. 2, 3. Pl. 1, fig. 6, 7.

"Trilobites sphæricus — capite subtriangulari: glabella globulari, porrigente, ad basin utrinque tuberculo instructo; genis triangularibus, elevatis; sulco verticali profundo.

Hidtil har jeg af denne Art kun fundet ufuldstændige Hovedskjolde i Overgangsleerskifer paa det nye Slots tomt ved Christiania. Fig. 8 forestiller et saadant i naturlig størrelse, seet fra Bagsiden."

Remarks: In describing the Baltic trilobites Schmidt (1881 p. 160) establishes a new species *Cheirurus (Cyrtometopus) aries* Schmidt. He quotes, however, that in L. v. Buch's collection in Berlin, he had seen Norwegian specimens which were identical with the Baltic species. He therefore gives as synonyms Esmark's *Tr. sphæricus*, Sars' *Calymene clavifrons* (text-fig. 4, *8*) and Angelin's *Sphærexocus* (?) *clavifrons* (Sars) (Angelin 1851—1878, p. 75, pl. 38, fig. 18 a, b) but says that he will maintain his name provisionally.

The Baltic species occurs in C_1 which corresponds well with the Ogygiocaris — Ampyx-beds (4 a α—4 a β) forming the ground of the Royal Palace in Oslo on which the types were found.

The old collection has three specimens labelled *Tr. sphæricus*. They are not from the type locality, but from Løken, Ladegaardsøen (Bygdøy) just as the specimen described by Sars. The figured specimen (pl. 1, fig. 6, 7) might be the type of Sars (text-fig. 4, *8*). The specimens are preserved in a dark calcareous shale (probably 4 a) and the specimens seem well enough preserved to maintain Esmark's species which has priority over Schmidt's species.

Concerning the generic name, I have included the species in the genus *Hemisphærocoryphe* Reed as indicated by Warburg (1925, p. 387).

Neotype: No. 61747 Pal. Mus. Oslo Coll. (Pl. 1, fig. 6, 7).

(*Trilobites semilunaris* Esmark.)

Text-fig. 2.

"Trilobites semilunaris — capite marginato, angulis mucronatis semilunari: glabella antice latiore, transversim sulcata; oculis ad latera glabellæ sitis.

Paa Exemplaret hvorefter Beskrivelsen og Afbildningen — Fig. 9 i naturlig Størrelse — er tagen, er Panden og Øinene utydelige, og den bagere Deel af Legemet skjult i Stenen. Den er fra Langöen ved Holmestrand i Overgangskalk."

Remarks: I have not been able to find any specimen of this species from the Ludlowian beds of Langøy, Holmestrand. Boeck (1838, p. 140) mentions that the species was founded on an incomplete and indifferent specimen. For this reason it seems necessary to discard the species.

4. *Cybele dentata* (Esmark) = *Trilobites dentatus* Esmark.

Text-fig. 2, pl. 1, fig. 5.

"Trilobites dentatus — et Haleskjold mærkelig ved tandformige Spidser paa den bagerste Rand er fremstillet ved Fig. 10 i dobbelt Størrelse. Som tydelig adskildt fra Haleskjoldet hos andre hidtil beskrevne Arter af Trilobiter, bør dette blive opført som tilhørende et eget Species, hvilket kunde indtil videre charakteriseres: Pygidii rhachide caudali distincta, dense annulata, costis deorsum vergentibus in spinas ocutass abientibus."

Remarks: Several specimens of the old collection are marked with the present name. Some, however, are undoubtedly *Cybele bellatula* Dalm. and occur in the brownish Expansus Shale (3 c β) characteristic of that species. The other specimens are preserved in a grey shale of somewhat younger age (4 a—4 b?).

Angelin (1851—1878, p. 89, pl. 41, fig. 12) maintains Esmark's species and includes also *Tr. plicatus* of Boeck (1838, p. 140). The latter form, however, is identical with *Cybele bellatula* Dalm. as I could make out from a specimen labelled under Boeck's name.

The specimens from the shale correspond well with Angelin's drawing and also partly with Esmark's less successful reconstruction. Brøgger (1882, p. 136) also finds *C. dentata* (Esmark) to be different from *C. bellatula* Dalm.

Lectotype: No. 56 161 Pal. Mus. Oslo Coll. (Pl. 1, fig. 5).

1835. M. Sars: "Über einige neue unvollständig bekannte Trilobiten."

The illustrations are reproduced in text-figs. 3, 4. The author describes five new species of which one has been identified as a previously described form. Sars also describes *Ogygiocaris dilatata* (Brünnich) (text-fig. 3, *5 a*, *5 b*), *Cyrtometopus clavifrons* (Dalm.) (text-fig. 4, *7*), *Hemisphærocoryphe sphæricus* (Esmark) (text-fig. 4, *8 a*, *8 b*), and the hypostoma of *Asaphus expansus* (Linn) (text-fig. 4, *9 a—9 c*) and *Illænus esmarkii* (Schlotheim) (text-fig. 4, *10*).

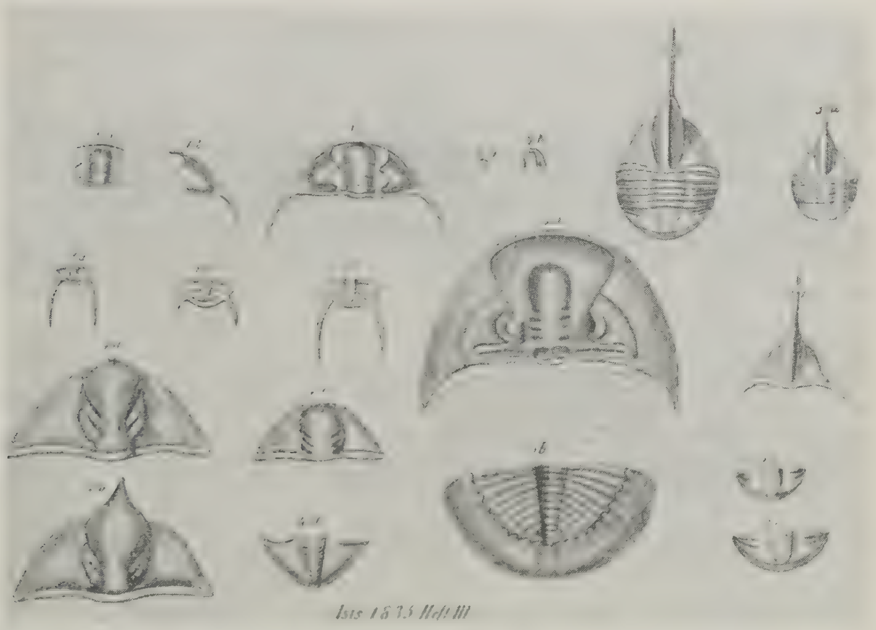
1. *Ceratopyge forficula* (Sars) = *Olenus forficula* Sars.

Text-fig. 3, *1 a—1 f*, pl. 1, fig. 8—11.

"In einem zum Theil kalkhaltigen schwarzgrauen Alaunschiefer von Ruseløkbacken bey Christiania kommen die Bruchstücke von einem Trilobiten vor, welche ohne Zweifel zu einer Gattung der Sippe Olenus Dalm. (Paradoxides Brongn.) gehören; Kopf und Schwanzschild finden sich an bemeldter Stelle in grosser Menge, und da man sonst keine andern Trilobiten, eine Gattung Battus ausgenommen, daselbst antrifft, so werden die Vermuthungen, dass diese Theile ein und derselben Gattung angehören, fast zur voller Gewissheit. Vom Kopfschild werden Stirntheile und die 2 Seitentheile gefunden, doch nur abgesondert jedes für sich. Stirntheil (Glabella) ist convex, länglich, vorn breiter als hinten, hat zugleich 2 undeutliche Querfurchen, in der Mitte des vordern Endes einen Eindurck oder eine kurze Längsfurche und endlich hinten eine kleine Spitze in der Mitte. Die Nath oder sogenannte Gesichtslinie (Linia facialis Dalm.) ist ziemlich gleich der des Trilobites minor Boeck, welcher dem Olenus tessini nahe steht (vergl. Magazin for Naturvidensk., Christiania 1827. Heft I, Fig. 12). Längs dieser Linie pflegen bey den meisten mir bekannten Trilobiten die Seitenstücke (Genae) des Kopfschildes sich leicht von dem Stirntheile zu trennen. Solche einzelne lose Stücke sind eine allgemeine Erscheinung in unsern Kalkbergen. Ebenso finden sich auch ganz abgesonderte Seitenstücke des gegenwärtigen Trilobiten; setzt man sie an einen Stirntheil, wo sie natürlicher Weise am genausten passen; so bekommt man den Kopfschild ganz vollständig, F. 1 c. Man sieht alsdann, dass der hinterste Winkel oder Eck auf jeder Seite in ein zugespitztes, etwas gekrümmtes Horn ausläuft und das rund um den halbkreisförmigen Kopfschild eine deutliche Kante geth. Die Backen sind etwas convex.

Der Rumpf oder Mittelleib (Truncus) ist unbekannt; aber der sonderbare Caudalschild findet sich häufig und zwar von sehr verschiedener Grösse, F. 1 d. e. f. Er ist halbskreisförmig, hinten mit einer Kante; der mittlere Lappen (Rachis pygidii) ist stark erhöht und besteht aus 5—6 Ringeln, welche ziemlich deutlich sind; die Seitenlappen mehr flach oder nur ein wenig convex mit 2 starken Querfurchen (sulci); die vordere mit Wülsten, die andere mit Stacheln. Was nehmlich am meisten den Schwanzschild auszeinet, sind 2 Stacheln, einer auf jeder Seite, welche am Ende zugespitzt, hinten grad ausgestreckt und ein wenig einwärts gekrümmt sind. Sie sind von verschiedener Länge an den verschiedenen Schwanzschildern, nehmlich 1—2½ mal länger als der Caudalschild selbst. Sind das aber blosse Variatäten oder vielleicht Andeutungen von mehreren sich ähnlichen Gattungen?

Sowohl hinsichtlich der Charactere des Kopfschildes, als und zwar vornehmlich des Schwanzschildes, ist demnach dieser Trilobit bestimmt verschieden von allen mir bekannten. In dem Schiefer, worin er sich findet, kommen sonst keine anderen organischen Ueberreste vor, als ein kleiner Battus, ein Paar Fucoiden, Anomites lenticularis Wahlenb. und eine gestreifte Terebratula. Die Trilobiten sind theils glänzend schwarz, theils weiss und verkalkt, wo sie der Einwirkung der Luft ausgesetzt waren."



Text-fig. 3. Norwegian trilobites figured by Sars 1835. Fig. 1 a—1 f = *Ceratopyge forficula* (Sars) (= *Olenus forficula* Sars), fig. 2 a—2 b = *Shumardia pusilla* (Sars) (= *Battus pusillus* Sars), fig. 3 a—3 e = *Lonchodomas rostratus* (Sars) (= *Ampyx rostratus* Sars), fig. 4 a—4 b = *Ampyx costatus* (Boeck MS) (= *Ampyx mammilatus* Sars), fig. 4 c—4 d = *Ampyx mammilatus* Sars, fig. 5 a—5 b = *Ogygiocaris dilatata* (Brünnich) (= *Asaphus dilatatus* (Dalm., Sars), No. 20287 Pal. Mus. Oslo Coll. Reproduced in ²/₃×.

Remarks: The type specimens of Sars were collected from the Ceratopyge Shale (3 a β) Ruseløkken in Oslo. The old collection has numerous labelled specimens from this type locality. It has been difficult to find the actual types, but the cranidium pl. 1, fig. 9 evidently represents the specimen figured by Sars (text-fig. 3, *1 a*) and by Brøgger (1882, pl. 3, fig. 17). The size is the same and also the small pit in the frontal portion of the glabella.

The free cheek (pl. 1, fig. 8) and the pygidiæ (pl. 1, fig. 10, 11) are also from the type locality.

Lectotype: No. 42690 a Pal. Mus. Oslo Coll. (Pl. 1, fig. 9).

Hypotypoids: Nos. 56197 b, 42690 b, 56199 Pal. Mus. Oslo Coll. (Pl. 1, fig. 8, 10, 11).

2. *Shumardia pusilla* (Sars) = *Battus pusillus* Sars.

Text-fig. 3, *2a*, *2b*, pl. 1, fig. 13.

"Den sehr kleinen Battus, welcher hier [in dem Schiefer mit Ceratopyge] ziemlich häufig vorkommt, habe ich anderwärts nicht angetroffen. Er ist ganz verschieden von Battus pisiformis, von Gestalt halbkreisförmig; der Mittellappen, welcher vorn an jeder Seite einen kleinen halbmondförmigen Fortsatz hat, ist, das vorderste Ende ausgenommen, mit tiefen Furchen von den Seitenlappen geschieden; hinten hat er eine Kante oder einen Wulst. Man könnte diese neue Gattung Battus pusillus nennen."

Remarks: The old collection contains a number of specimens from the type locality (Ruseløkken = Sophienberg near Drammensveien) which is the same as for the preceding species. The small species occurs in great quantities in the shale and might serve as a guide fossil for this zone just as in Sweden. A detailed description of the species is given by Stubblefield (1926).

Lectotype: 56430c Pal. Mus. Oslo Coll. (Pl. 1, fig. 13).

3. *Lonchodomas rostratus* (Sars) = *Ampyx rostratus* Sars.

Text-fig. 3, 3a—3e, pl. 2 fig. 1—4.

"Das lange Horn vorn an der Stirn gibt dem in Fig. 3 abgebildeten kleinen, ziemlich breiten und rundlichen Trilobiten ein höchst sonderbares Ansehen, wodurch er glänzlich von allen andern bis jetzt bekannten Gattungen abweicht, auch eine neue Form in der Sippschaft der räthselhaften vorweltlichen Thiere darstellt. Unter den bekannten Gattungen gleicht diese am meisten dem Ampyx nasutus Dalm, was sie aber sogleich unterscheidet, ist der, mit einer erhöhten Kante oder Crista in der Mitte nach der Länge ausgezeichnete, kegelförmig verlängerte Stirntheil, welcher in eine lange dünne pfriemenförmige Spitzte oder Horn ausläuft, das mehr als einmal länger ist als der Kopfschild. Obschon ich mit Grund vermuthe, daß A. nasutus auch ein ähnliches Horn habe, weil sich eine solche Bildung unverkennbar bey der folgenden, nur wenig von A. nasutus abweichenden, ja vielleicht wirklich gleichen Gattung, die ich sogleich beschrieben werde, findet; so gibt doch die so eben beschriebene Gestalt des Stirntheils sammt dem gänzlichen Mangel der bey jenem vorkommenden Seiteneindrücke oder Furchen an der Basis der Stirn hinlängliche Unterscheidungszeichen an die Hand.

Dass jedoch der Kopfschild bey Fig. 3a, nicht ganz vollständig ist, zeigt das besser erhaltene Exemplar Fig. 3c; hier sieht man, dass rundum eine Kante oder Rand sich findet, welcher hinten in den Ecken jederseits in ein Horn oder einen Stachel ausläft, deren Länge nicht angegeben werden kann, da beyde abgebrochen waren.

Der Rumpf bestand aus 5 Abschnitten, der mittelste Lappen (Rhachis) ziemlich breit und nicht sonderlich erhaben, die Seitenlappen auch breit. Jeder Abschnitt mit einer tiefen Querfurche. Dalmans A. nasutus hat nach seiner Schätzung 6

Abschnitte am Rumpfe; ob nun demnach die vorliegende Gattung vielleicht auch dieselbe normale Anzahl von Abschnitten hat, so dass einer von ihnen, was nicht so ganz selten bey den Trilobiten vorkommt, kann untergeschoben seyn, das bin ich nicht im Stande genau auszumachen, da ich nicht mehr als das einzige vollständige, Fig. 3 a. abgebildete, Exemplar erhalten habe.

Der Schwanzschild ist halbmondförmig und sein hinterster Rand mit einer niedergehenden dicken längsgestreiften Kante versehen. Der mittlere Lappen ist ziemlich breit und nicht sonderlich erhaben, glatt, ohne Spur von Segmenten oder Querfurchen, hatt aber statt derselben nur 6 Querreihen von runden, ziemlich flachen und sehr kleinen Knoten, 4 in jeder Reihe, welche die Segmente anzeigen. Die Seitenlappen sind ganz glatt, nur haben sie vorn an den Seiten 2 characteristische Querfurchen. Demnach ist auch der Schwanzschild bey der vorliegenden Gattung sehr ausgezeichnet.

Man wird sehen, wie viel Uebereinstimmung hier zwischen dieser und der folgenden Gattung mit Dalman's A. nasutus herrscht. Es ist daher ohne Zweifel am besten, dieselben von Asaphus zu unterscheiden, von dem sie ganz abweichen durch den vollkommenden Mangel der Augen, durch die geringe Anzahl der Segmente und die conisch verlängerte Gestalt des Stirntheils; sie bilden alle drey eine sehr verschiedene natürliche Sippe, welche den Namen Ampyx behalten könnte, da er einmal eingeführt ist. Ebenso kommt vielleicht auch Asaphus granulatus unter die Sippe, welcher er fast in Allem gleicht (dessen Rumpf hat wirklich 6 Segmente, wovon ich mich durch vollständige Exemplare aus unsern Bergen überzeugt habe), um so mehr als ich bey verschiedenen Exemplaren in der Mitten der Stirn eine Spur von einem dünnen Stachel in einer kleinen kreisrunden Warze gefunden habe, welcher deutlich abgebrochen war.

Ampyx rostratus kommt in unserem allgemeinen schwarzen Uebergangskalkstein bey Ladegaart's Öen und Hjortnaestangen bey Christiania vor, doch nicht so häufig, wie die folgende Art, in Gesellschaft mit verschiedenen Gattungen Asaphus, Calymene, Orthoceratites, Lituiten, Schnecken usw. Seine Grösse ist allgemein wie Fig. 3 a. zeigt; doch kommen auch Kopfschilder so gross vor, wie Fig. 3 c."

Remarks: In the old collection a number of specimens from the type locality: Huk, Ladegaardsøen (Bygdøy) are labelled as belonging to this species. The pieces containing the specimens on pl. 2, fig. 2, 4 are also specially marked as types of Sars and the former evidently represents one of the nearly complete specimens on which he based his reconstruction (text-fig. 3, *3 a—3 b*) and the latter, the figured pygidium (text-fig. 3, *3 d—3 c*).

In order to demonstrate the structure of the prismatic frontal spine, I have cleaned one specimen from the original collection (pl. 2, fig. 3). The broad steep and striated posterior border of the pygidium is not well demonstrated in the photographs.

The species occurs more or less abundantly in the zones 4 a α and 4 a β of the Oslo region. The species must be regarded as the genotype of *Lonchodomas* Angelin.

Lectotype: No. 56407, Pal. Mus. Oslo Coll. (Pl. 2, fig. 2).

Hypotypoids: Nos. 61749, 61750, Pal. Mus. Oslo Coll. (Pl. 2, fig. 1, 3).

Paratypoid: No. 56404, Pal. Mus. Oslo Coll. (Pl. 2, fig. 4), (text-fig. 3, *3 d*, *3 c*).

4. *Ampyx mammilatus* Sars = *Ampyx mammilatus* Sars (spec. nov.?).

Text-fig. 3, *4 c*, *4 d*, pl. 2, figs. 5—12.

"Dieser gleicht noch mehr als die vorhergehende Gattung dem A. nasutus Dalm. (Paläaden p. 68 t. 5 f. 3), scheint aber vornehmlich darinn abzuweichen, dass die Stirn an der Basis jederseits eine ziemlich grosse und flach-ovale Erhöhung hat, welche mit Furchen begränzt ist sowohl oben als unten an den Seiten, mit einer kleineren Furche in der Mitte. So fand es sich beständig bey allen mir vor Augen gekommenen Exemplaren. Es kann wohl seyn, dass diese Charactere bey Dalmans Exemplaren nicht deutlich gewesen sind, und dass mein Trilobit mit dem seinigen einerley ist; das mag indessen dahingestellt bleiben, bis eine nähere Aufklärung und Vergleichung mit der schwedischen Gattung möglich ist.

Die Stirn ist wie bey A. nasutus stark erhöht, und läuft über den vordern Rand hinaus, endigt sich aber nach vorn in eine conisch zugespitzte Warze, welche zwar meistens sich abgebrochen findet, aber doch bey einzelnen Exemplaren, Fig. 4 b., deutlich aussieht als wäre es ein verlängerter Stachel, der ohne Zweifel dünn und lang gewesen wie bey dem so eben beschriebenen A. rostratus. Uebrigens ist die Stirn bald mehr, bald weniger hervorgezogen, und mehr oder weniger erhöht, F. 4 c. Die vorderste Kante des Kopfschildes ist deutlich gerändert und ein wenigt vertieft; diesen vertieften Rand findet man aber nicht an dessen Seiten, wesshalb hier ohne Zweifel ein solches Stück oder Rand auswendig herumläft, wie bey A. rostratus› F. 3 c. Kopfschilder von diesem Trilobiten, wovon bis jetzt keine vollständigen Exemplare gefunden wurden, kommen von sehr verschiedener Grösse vor, nehmlich von einem halben bis zu anderthalb Zoll in der Breite in Uebergangskalkstein an denselben Stellen, wo die vorige Gattung, zum Theil in Menge. In Gesellschaft mit diesem Kopfschild findet sich auch häufig ein Schwanzschild, wovon man mit ziemlicher Sicherheit vermuthen darf, dass er zu derselben Gattung gehört. Er ist dreyeckig F. 4 d; am hintern Ende etwas zugespitzt; die Seiten haben eine dicke längsgestreifte Kante Der mittlere Lappen ist convex mit vielen Querstreifen oder Ringen, die Seitenlappen schwach quergestreift; am vorderen Rand sieht man eine stark vertiefte Furche (sulcus)."

Remarks: As described below, Sars evidently mixed two different species under the present specific name. He states that the size of the cephalon varies considerably, from ½ inch to 1½ inch, His illustrations of the larger form (text-fig. 3, *4 a*, *4 b*) differ also from that of the smaller one (text-fig. 3, *4 c*).

It appears, however, that Sars' species was later divided by Boeck into two separate species. In 1854 Angelin (1851—1878, p. 80, pl. 40, fig. *1—1 e*) presents *Ampyx costatus* Boeck and refers to it fig. 4 a, 4 b, 4 d in Sars' paper to this species. Boeck has not described this species, but he indicates (Boeck 1838, p. 144) the possible presence of a new species. In the old collection specimens are relabelled *Ampyx costatus*. The name is evidently a manuscript name as listed by Kummerov (1928, p. 3). Probably Boeck suggested this name to Angelin.

With regard to the true *A. mammilatus* Sars, it is well represented in the old collection. The type of fig. *4 d* is distinguished as original on the old label. Sars' drawing of the cephalon (*4 c*) is not very successful and it has not been possible to identify the actual type-specimen among the cotypes of which several are figured pl. 2, fig. 5, 6, 8, 9, 10, 11, 12. The size of the cephalae shows in general little variation, being about 6 mm in length (without spine). Larger ones up to 9—10 mm occur.

The species has the following characteristics: The short glabella does not protrude over the frontal margin. The glabellar spine, if present (?), is rudimentary. The glabellar furrows are elongate. The pygidium has a steep posterior margin forming a sharp angle to the flat, almost smooth pleurae. The shape of the pygidium varies in relative length just as among other species of Raphiophoridae and Trinucleidae.

It is possible that the present species should rather be included in the genus *Raphiophorus*. Raymond (1925, p. 30), in discussing the genera of family Raphiophoridae, mentions that the genus *Raphiophorus* Angelin is distinguished from *Ampyx* by having 5 (instead of 6) thoracic segments, ovate instead of oval glabella and ribs on the pleural lobes of the pygidium. The number of thoracic segments is not known (at least in the type material) and provisionally it seems correct to maintain the genus *Ampyx*.

On the other hand *A. mammilatus* shows considerable relationship to *A. costatus* which has distinct ribs on the pygidium.

A. mammilatus Sars occurs commonly in the Ogygiocaris shale (4 a α) and the Ampyx Limestone (4 a β) (lower part?).

Lectotype: No. 56403, Pal. Mus. Oslo Coll. (Pl. 2, fig. 8, 9).

Paratypoid: No. 56393, Pal. Mus. Oslo Coll. (Pl. 2, fig. 7), (text-fig. 3, *4 d*).

Hypotypoids: Nos. 61749, 56401, 56396, Pal. Mus. Oslo Coll. (Pl. 2, fig. 5—6, 10—11, 12).

Ampyx costatus Boeck MS.

Text-fig. 3, *4 a*, *4 b*, pl. 2, fig. 13—18.

In addition to the preceding species, I have found it appropriate to figure and briefly describe the present species which by Sars originally was included in the former.

The species was for the first time illustrated and described by Angelin (1851—1878, pl. 40, fig. 1—1 e). Angelin's short diagnosis reads:

> "A. fronte lateribus depressis, foveolisque utrinque 4, posticis semicircularibus."

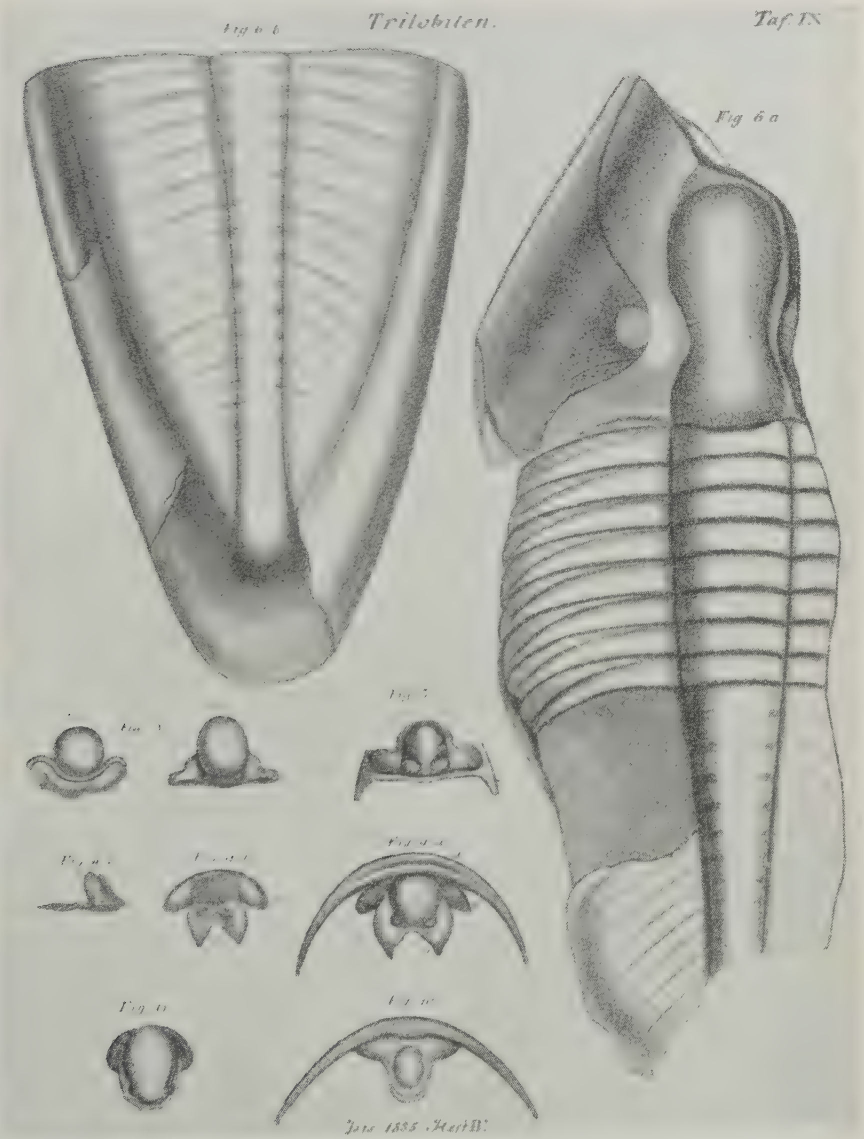
Brief description from type material: Cephalon of nearly semi-circular outline, glabella with flat lateral fields or alæ, oval, not much vaulted and protruding over the frontal margin. The frontal portion of glabella prolonged into spine of unknown length. Three pairs of glabella furrows distinct, appearing as round or oval depressions. Fixed cheeks smooth and uniformly convex. Occipital segment distinct. Free cheeks and thoracic segments unknown. Pygidium triangular in outline with moderately inclined posterior border without a sharp upper edge. Pleural lobes gently convex with distinct, oblique ribs.

The species occurs in the Ampyx Limestone (4 a β) and probably also in the Ogygiocaris Shale (4 a α). Brøgger (1887, p. 18) also quotes the species from the Orthoceras Limestone (3 c γ) but this seems less probable and the species is not listed from this zone in his earlier paper (1882, p. 25—28).

As mentioned under the preceding species, it is possible that the present form belongs to the genus *Raphiophorus* rather than *Ampyx*, but provisionally the genus *Ampyx* is maintained as long as the number of thoracic segments has not been established.

Lectotype: No. 56399, Pal. Mus. Oslo Coll. (Pl. 2, fig. 13—15).

Hypotypoids: Nos. 56404, 56405, Pal. Mus. Oslo Coll. (Pl. 2, fig. 16—17, 18).



Text-fig. 4. Norwegian trilobites figured by Sars 1835. Fig. 6 a—6 b = *Megalaspis centaurus* (Dalman) (= *Asaphus grandis* Sars), 6 a = No. 20139 Pal. Mus. Oslo Coll.; fig. 7 = *Cyrtometopus clavifrons* (Dalman) (= *Calymene speciosus* Sars), fig. 8 a—8 b = *Hemisphærocoryphe sphæricus* (Esmark) (= *Calymene clavifrons* Sars), fig. 9 a –9 c) = Hypostomal structures of *Asaphus expansus* (Linn.), fig. 10 = The same in *Illænus esmarkii* (Schlotheim), fig. 11 = Hypostoma of *Ogygiocaris dilatata* (Brünnich) (= *Asaphus dilatatus* Dalm. Sars). Reproduced in $^2/_3\times$.

(*Asaphus grandis* Sars=*Megalaspis centaurus* (Dalman)).

Text-fig. 4, *6 a*, *6 b*.

"Das einzige, mir bis jetzt vor Augen gekommene, doch nicht ganz vollständige Exemplar von diesem ansehnlichen Trilobiten findet sich im schwarzen Kalkstein von Aggersbakken bey Christiania. Er scheint unter den bekannten Gattungen am meisten dem A. extenuatus Dalm. zu gleichen; unterscheidet sich aber merklich durch seine ausgezeichnete Stirn, welche stark convex ist, länglich, vorn zugerundet, mitten etwas eingekniffen mit einigen undeutlichen Eindrücken an jeder Seite. Die Gesichtslinie scheint im Wesentlichen denselben Lauf zu haben wie bey dem vorhergenannten Trilobiten und sie geht vielleicht ebenso vorn in eine Spitze aus, was ich jedoch an meinem Exemplar nicht bemerken konnte, da dessen vorderstes Ende abgebrochen war. Nur ist der Bogen, den diese Linie vom Auge an und vorwärts macht, sehr gross, ebenso ist die hinterste Ausbiegung verhältnissmässig gross. Das Auge, welches übrigens abgebrochen war, ist auch viel kleiner als bey A. extenuatus; es sitzt aber an den convexesten Seitentheilen (genae) des Kopfschilds, welche an den Seiten und vorn stark niedergehen, bis wieder der äussere Rand sich nach oben hebt. Ob dieser letzte Theil an den hintern Ecken zugerundet ist oder in ein Horn endigt, wie bey so vielen Trilobiten, weiss ich nicht, weil mein Exemplar an dieser Stelle nicht ganz war.

Der Rumpf besteht aus der gewöhnlichen Anzahl von 8 Segmenten; doch ist dessen mittlerer Lappen (Rhachis) verhältnissmässig nicht so breit als bey A. extenuatus.

Der Schwanzschild war, wie F. 6 a. ausweiset, sehr beschädigt und abgebrochen, dennoch sieht man an dem übrig gebliebenen so viel, dass er von demselben Theil bey A. extenuatus sehr verschieden ist; denn obschon er ziemlich glatt ist, so ist er doch nicht ohne Spur von Segmenten und zwar hat nicht allein der mittelste viele dergleichen sehr deutliche (ich zählte 12, indessen mangelte, wie schon bemerkt, ein grosser Theil vom hintersten Ende), sondern auch die Seitenlappen haben schöne, sehr schwache und schmale Rippen. Indessen weicht die Gestalt des mittlern Lappens am meisten ab, indem er viel länger und schmäler ist, als bey A. extenuatus, und hinten etwas breiter als in der Mitte zu werden scheint.

Bis eine vollständige Beschreibung vom Schwanzschild dieses Trilobiten gemacht werden kann, mag etwa die Abbildung, F. 6 b., von einem riesenhaften Schwanzschild, welcher auf derselben Stelle wie das so eben beschriebene ganze Exemplar gefunden worden, dienen. Dieser Schwanzschild, welcher übrigens nicht frey von Beschädigung und ziemlich abgeschliffen ist, zeigt zugleich eine durchgängige Gleichheit von einer nach hinten zugespitzten Form mit demselben Theil wie bey A extenuatus, als das am meisten characteristische Kennzeichen den sonderbar langen und schmalen Mittellappen. Uebrigens ist er ziemlich glatt, mit Ausnahme des Mittellappens, welcher eine Menge Eindrücke oder Andeutungen von Ringen (gegen 20) hat, und die Seitenlappen schwache, sehr schmale Rippen, welche sich nach der Anzahl der Ringe des Mittellappens richten. Hinten endigt er zuletzt in einen runden, ziemlich breiten und flachen Knoten. Der Rand ist breit und ganz glatt; er ist sehr dick, was man an den hie und da abgebrochen Stücken des Exemplares sieht, wornach unsere Abbildung verferdiget ist. Das hinterste Ende war etwas

zugerundet. Ausser diesem besitzte ich noch einen Schwanzschild, welcher dem so eben beschriebenen gänzlich gleicht und nur viel kürzer und breiter ist. Falls also dieser beschriebene Schwanzschild zu unsere früher beschriebenen Gattung gehört, was nicht zweifelhaft zu seyn scheint, so muss sie eine Grösse von ziemlich einem Schuh erreicht haben, und demnach eine von den grössten aller bekannten Trilobiten seyn."

Remarks: In his monograph on the Illænidae, Holm (1882, p. 50) points out that Dalman (1827) had described some large fragments which he named *Illænus centaurus.* On examining the type material, Holm found that these fragments belong to the species later described by Sars as *Asaphus grandis.* He therefore suggested to replace Sars' species with *Megalaspis centaurus* (Dalman). Schmidt (1906, p. 54) follows Holm and the two species *M. multiradiata* Angelin (1851—1878, p. 16, pl. 14, fig. 2) and *M. rudis* Angelin (l. c., p. 50, pl. 27, fig. 5) are regarded as varieties of *M. centaurus* (Dalman).

The old collection contains several specimens labelled as *Tr. grandis* Sars. Among them is the nearly complete type of Sars (text-fig. 4, *6 a*). Some of the other specimens belong to other species such as *Megalaspis acuticauda* Angelin and *M. heros* Angelin.

1838: C. Boeck "Uebersicht der bisher in Norwegen gefundenen Formen der Trilobiten-Familie."

Boeck described a number of new species among which several are given manuscript names by Sars and Boeck. In the sequel, the introduction and the descriptions of new species are cited.

"Unter den in Norwegen vorkommenden thierischen Ueberresten, welche in den, Petrificate enthaltenden, Gliedern der sogenannten Uebergangsformation gefunden werden, bilden die Trilobiten eine merkwürdige Reihe, da theils an einigen Orten eine unglaubliche Menge von Individuen derselben zusammengehäuft erscheint, theils die Menge der Arten bereits ziemlich beträchtlich ist. Dennoch sind bisher nur sehr wenige arten beschrieben oder erwähnt worden. Ein vollständigerer und genauerer Bericht lässt sich auch dazumal besonders deswegen nicht abstatten, weil man bisher von den meisten Arten nur unvollkommene Specimina erhalten hat. Eine Uebersicht der deutlich verschiedenen Formen, wie sie sich nach Exemplaren, die in mehreren Sammlungen aufbewahrt sind, unterscheiden lassen, wird indess als Wegweiser bei fortgesetzten Untersuchungen und zur Vergleichung der Verhältnisse der Menge der Versteinerungen in verschiedenen Gegenden dienen, sollte sie auch in manchen Stücken weniger vollständig seyn, als man sie wohl gern haben möchte. Der hier gelieferten Ausarbeitung ist, ausser den von Brünnich,[1] Schlotheim,[2]

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[1] Beskrivelse over Trilobiten en Dyreslægt, siehe Nye Saml. af det Kongl. Danske Vidensk. Selsk. skrifter, 1ster Theil, 1781.

[2] Beschreibung einiger abgebildeten Arten von Echinosphäriten und Trilobiten, siehe Isis 1826.

M. Esmark[3] und Sars[4] ans Licht gestellten Beschreibungen norwegischer Trilobiten, besonders eine von Hrn. Sars und dem Verfasser entworfene und dem physiographischen Vereine allhier in dessen Versammlung im Februar 1829 vorgelegte Notiz über die bis dahin in Norwegen gefundenen Trilobiten zu Grunde gelegt. Späterhin sind mehrere neue Beobachtungen über die norwegischen Trilobiten durch Besichtigung der Petrificatsammlungen des Herrn Professors Esmark und der hiesigen Universität hinzugekommen, welche letzere neulich mit einer Anzahl vortrefflicher Specimina, die ihr Hr. Pastor Sars überlassen hat, vermehrt worden ist. Da der Verfasser vor kurzem Gelegenheit gehabt hat, die in Lund befindlichen Trilobiten in den Sammlungen des Herrn Professors Nilsson und zum Theil der Universität, in Stockholm in der Sammlung der Akademie der Wissenschaften und in Upsala in den Sammlungen des Herrn Amanuensis Marklin und der Gesellschaft der Wissenschaften in Augenschein zu nehmen, welche den grössten Theil der Originale der von Wahlenberg und Dalman aufgestellten Arten enthalten, so ist es möglich gewesen, schon zuvor beschriebene Formen von vermuthlich neuen mit grösserer Bestimmtheit zu unterscheiden und einige Fehler der Synonyme zu berichtigen."

1. (*Trilobites elegans* Sars & Boeck MS).

Text-fig. 2, 7.

"Unter dem Namen Tr. elliptifrons beschreibt Hrr. M. Esmark am angeführten Orte eine Art von der Insel Malmöekalven im Christianiafjord, welche dadurch charakteristisch seyn sollte, dass die prominentia weitgedehnt ellipttsch ist. Ist indessen der clypeus in Tab. VII, Fig. 6 richtig abgebildet, so gehört Fig. 7 nicht zu derselben Art; denn daducrh wird eine andere im Thonschiefer von Malmöekalven nicht selten vorkommende Art deutlich vorgestellt nämlich.

2. Tr. elegans, Ss. und Bk. Mscr., welcher eine prominentia trapezoidae hat. Hiezu wird wahrscheinlich als Synonym zu rechnen seyn Calymene macrophthalma, Brongniart, crust. foss. Tab. I, Fig. 5 A, B, C. In der Sammlung des Hrrn. Thamnau zu Berlin hat der Verfasser ein Trilobitexemplar aus der umgegend Königsbergs gesehen, welches dem von Malmøekalven völlig ähnlich ist."

Remarks: No specimen with this name has been traced in the old collection. Kjerulf (1865, p. 20) mentions the species as identical with *Phacops stokesi* Miln. Edwards and Kiær (1908) does not include *P. elegans* in his lists of Silurian species.

Recently Whittard (1938, p. 129—130) has studied the matter and arrived at the conclusion that the species has to be discarded and this opinion is followed here.

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[3] Om nogle nye Arter Trilobiter, siehe Magazin for Naturvidenskaberne, 2 Band, 1 Heft, 1833.

[4] Ueber einige neue oder unvollständig bekannte Trilobiten, siehe Isis, 1835.

2. (*Trilobites scaber* Boeck).

> "In der Sammlung des Hrrn. Professors Esmark findet sich ein nicht ganz vollständiges, doch recht charakteristisches Exemplar eines kleinen Trilobiten, welcher, wie der vorige, 11 Rückenglieder und ein abgerundetes scutum hat, dessen prominentia aber ziemlich stark erhoben und scharf granulirt ist, Tr. scaber mh. Er muss daher als verschieden von den angeführten betrachtet werden, und ist auch ganz verschieden von C. macropthalma Brongn., a. a. O. Tab. I, Fig. 4 A, B, wie auch von andern, von mehreren Verfassern mit diesem Namen bezeichneten, Trilobiten, imgleichen von den von Bronn Tr. Slottheimii benannten Arten. Uebrigens muss bemerkt werden, dass alle diese angeführten Trilobitformen ein sehr gut abgränztes Geschlecht bilden."

Remarks: Nor has this species been found in the old collection, and also on account of the indistinct description, the species has to be omitted.

3. *Chasmops conicophthalma* (Sars et Boeck MS) = *Trilobites conicophthalmus* Sars et Boeck.

Pl. 3, fig. 1–6

> "Der von Dalman in Vetenskaps-Academiens Handlingar, 1826. pag. 393, Tab. 11, Fig 1 d als Calymene sclerops var. angeführte Trilobit macht eine eigene von dem eigentlichen Tr. sclerops sehr abweichene Art. aus, Tr. conicophthalmus Ss. und Bk. Mscpt. Er kommt gewöhnlich in Thonschieferschichten auf Ladegaardsöen bei Christiania vor, und ward ebenfalls auf dem Bauplatze des neuen Schlosses gefunden. Das Original zur Abbildung Dalman's, welches sich in der Sammlung des Hrrn. Professors Nilsson befindet, ist auch aus der Gegend von Christiania."

Remarks: As it appears from the brief description, a specimen from the Oslo Region described by Dalman (1826), is regarded as belonging to this species. The specimen is said to be preserved in Nilsson's collection, but since the species was established on Norwegian specimens and several of the cotypes are preserved in the old collection, I have found it correct to choose one of the Norwegian specimens as a lectotype.

Angelin (1851—1878, pl. 7, fig. 5, 6) gives the first illustration of the complete dorsal shield. The drawing, however, is not very accurate. The characteristic shape of the cephalon is not illustrated, the eyes are too big, the genal spines too short and the rachis of the pygidium narrows more than in typical specimens.

Characteristic of the species is: The semi-elliptic outline (without genal spines) of cephalon. The small, distinct and vaulted lateral lobes of glabella. The conical bases of the small lateral eyes are strongly elevated with the surface of the palpebral higher than the top of the glabella. The pygidum broad with semi-circular outline.

The species is characteristic of the Lower Chasmops Shale (4 b α) and the Lower Chasmops Limestone (4 b β) and serves as guide fossil for these zones in the Oslo district.

Lectotype: No. 56148, Pal. Mus. Oslo Coll. (Pl. 3, fig. 3, 4).

Hypotypoids: Nos. 61750, 56154, 56153 a Pal. Mus. Oslo Coll. (Pl. 3, fig. 1—2, 5—6).

4. *Chasmops extensa* (Boeck) = *Trilobites extensus* Boeck.

Pl 3, fig. 7—11.

> "Eine dieser sehr nahestehende Art, Tr. extensus mh., ist neulich auf Gaasöen im Christianiafjord gefunden. Es ist insonderheit das scutum, was beide Arten sehr bestimmt unterscheidet, da es bei jener rotundato-semicirculare, bei dieser acuminato-triangulare ist. Anguli clypei sind an beiden sehr lang."

Remarks: The old collection has several good specimens from type locality Gaasøen (Gåsøya) near Oslo. One of these specimens is chosen as lectotype for this species which, for some unknown reason, has not been maintained in later descriptions. Only Norwegian fossil lists (e. g. Brøgger 1887) have applied the present name. Characteristic of the species is: The considerable size, the more subtriangular outline of the cephalon and the large, flat glabellar lobes. The bases of the fairly large lateral eyes not elevated, the surface of palpebral lobes and top of glabella equally elevated. The pygidium narrow with parabolic posterior outline.

Chasmops extensa (Boeck) of the Oslo district seems not to have been figured.[1] It seems possible that the Swedish species *Chasmops macroura* Sjögren, described by Angelin (1851—1878, p. 9, pl. 7, fig. 3—4) might be identical with the present form. They correspond in the major characteristics, but the identity has to be solved after a study of the type specimen of *C. macroura*.

The Norwegian species is which well illustrated through the still existing cotypes, has to be maintained as a valid species (Boeck l. c., p. 139) also indicate the presence of a third species resembling *C. extensa*, a specimen which is said to be from Norway, preserved "im Frankfurter Museum".

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[1] A complete specimen from Norderhoug, Ringerike, is figured by K. O. Bjørlykke (Norges Geol. Unders. No. 25) and referred to this species.

Chasmops extensa (Boeck) is characteristic of the Upper Chasmops Shale (4 b γ) and Limestone (4 b δ) and serves as guide fossil for these zones in the Oslo district.

Lectotype: No. 56167 Pal. Mus. Oslo Coll. (Pl. 3, fig. 7—9).

Hypotypoid: No. 56165 e Pal. Mus. Oslo Coll. (Pl. 3, fig. 10, 11).

5. *Apatocephalus serratus* (Boeck) · *Trilobites serratus* Boeck.

"In Kalknieren in der Nähe der Kirche von Agers bei Christiania sind Bruchstücke eines Trilobiten, Tr. serratus mh., scuto semicirculari, margine serrato, gefunden worden. Es möchte wohl nach der Abbildung, welche Dalman von seiner Calymene actinura in Vetenskaps-Acad. Handl. 1824 Tab. IV, Fig. I A, B, C giebt einige Vermuthung obwalten, als gehöre Tr. serratus hieher, allein bei genauer Besichtigung des originalen Exemplars in der Sammlung der Akademie der Wissenschaften scheint es dem Verfasser, als spreche in der That vieles für Dalmans Vermuthung, dass seine Cal. polytoma und Cal. actinura Synonyme seyen; jedenfalls hat das scutum der letzteren nur eine entfernte Aehnlichkeit mit demjenigen unsers Tr. serratus."

Remarks: The old collection includes pygidiæ of this species which is well illustrated by Brøgger (1882, pl. 3, fig. 7, 8, 14). The cephalon and pygidium were primarily referred to different genera and species and then later combined in the genus *Apatocephalus* by Brøgger (1896).

Lectotype: No. 61751 Pal. Mus. Oslo Coll.

6. *Acidaspis armata* (Sars et Boeck MS) = *Trilobites armatus* Sars and Boeck.

Pl. 1, fig. 12.

"Hr. Sars hat in schwarzem Schiefer in der Nähe von Christiania das scutum einer dritten Trilobitenart gefunden, welche wie die obigen einen margo dentatus hat; allein bei dieser Art, Tr. armatus Ss. & Bk. Mscr., ist der eine Zahn verhältnissmässig viel länger als die übrigen, und überdies doppelt. Uebrigens scheint nicht Tr. armatus dem Tr. dentatus und Tr. serratus, aber wohl dem Tr. spinulosus Wahlb. sehr nahe zu stehen, welcher auch ein scutum dentatum hat, was Wahlenberg wegen der Undeutlichkeit des originalen Exemplars in der Universitäts-Sammlung zu Lund übersehen hat."

Remarks: One specimen labelled with this name occurs in the old collection. Although the pygidium figured is rather incomplete, the central and posterior portions are well enough preserved to maintain the species.

The locality is given as "Christiania?", but the metamorphic black shale strongly indicate, the Trinucleus Shale of the Brevig district.

Lectotype: No. 56150 Pal. Mus. Oslo Coll. (Pl. 1, fig. 12).

(*Trilobites plicatus* Sars et Boeck MS
=*Cybele bellatula* (Dalman)).

"Eine dritte Art, Tr. plicatus Ss. & Bk. Mscr., von Sars bei Christiania gefunden, welche sich dadurch unterscheidet, dass die an den Seiten der prominentia erscheinenden sulci einander sehr nahe, mithin die zwischenliegenden lobi sehr schmal sind."

Remarks: The specimen from Akersbakken (3 c β) given this name, belongs to Dalman's species.

(*Trilobites acicularis* Sars et Boeck MS
=*Ceratopyge forficula* (Sars)).

"Tr. acicularis Ss. & Bk. Mscr. welcher sich dadurch auszeichnet, dass spina scuti weit kürzer und schmaler ist, als bei Tr. forficula, während rachis scuti ziemlich genau dieselbe Form Zeigt,"

Remarks: As pointed out by Brøgger (1882, p. 124), Sars and Boeck refered specimens of *Ceratopyge* from the Ceratopyge Limestone (3 a γ) to this species while *C. forficula* (Sars) was characteristic of the Ceratopyge Shale (3 a β). Evidently the different mode of preservation might make some difference in the thickness of the spines. Brøgger maintained Sars and Boeck's species as a variety, but as long as the variety is not well established it might provisionally, at least, be discarded.

(*Trilobites Lyra* Sars et Boeck MS
=*Ceratopyge forficula* (Sars)).

"Tr. Lyra Ss. & Bk. Mscr., bei welchem rachis scuti kürzer und breiter ist, als bei den vorigen, und um so weniger sulci hat. Die spinae scuti haben überdies divergirende Spitzen, so dass das ganze scutum fast das Aussehen einer Lyra, wie dieses Instrument zum öftern abgebildet wird, erhält."

Remarks: This form from the Ceratopyge Shale (3 a β) was also placed by Brøgger (l. c.) as a variety of *Ceratopyge forficula* (Sars). The type specimen figured by Brøgger is evidently lost and other specimens have not been traced. It seems correct to discard this variety as long as considerable variation in length and shape of the spines might occur in the typical species.

7. *Asaphus raniceps* Dalman, var. *acuminatus* (Boeck) = *Trilobites acuminatus* Boeck.

"Von Tr. raniceps unterscheidet sich diese neue Art:

25. Tr. acuminatus mh. dadurch, dass sie weit grösser ist und gröbere und entferntere Streifen an der untersten Schale des scutum hat."

Remarks: Some of the old specimens labelled as *Tr. acuminatus*, belong to *asaphus expansus* Linn. An incomplete specimen, however, has the characteristic spaced striæ which, together with the more triangular cephalon, is characteristic of the variety. As indicated also by Brøgger, Schmidt (1898 p. 33) regards the present form as a variety of Dalman's species.

Lectotype: No. 56254 Pal. Mus. Oslo Coll.

8. *Megalaspis limbata* (Boeck) = *Trilobites limbatus* Boeck.

"Tr. limbatus mh. ist eine dritte Art, welche auch dem Tr. expansus ähnelt, aber durch anguli clypei mucronati und sutura antice acuta gleichsam einen Uebergang zu Tr. angustifrons macht, mit welchem sie auch die grössere Breite gemein hat. Ueberdies bildet die untere Schale des scutum bloss einen schmalen mit margo posterior paralellen Gürtel, der sehr feine Streifen hat. Diese hier mit dem Namen Tr. limbatus angeführte Art steht einer in Schweden vorkommenden sehr nahe, welche in der Sammlung des Hrr. Amanuensis Marklin zu Upsala unter dem Namen Tr. medius niedergelegt, aber doch davon ganz verschieden ist."

Remarks: This important species, which is well represented in the old collection, was described in detail by Brøgger (1882, p. 77—79). Brøgger illustrates on pl. 9, fig. 2, the pygidium of a nearly complete specimen of the old collection from Akersbakken in Oslo. The specimen corresponds exactly with the complete specimen (pl. 9, fig. 1) so well illustrated by Brøgger. I have chosen the old specimen from Akersbakken as the lectotype of the species.

Lectotype: Nr. 1631 Pal. Mus. Oslo Coll. (Brøgger 1882, Pl. 9, fig. 2).

9. *Asaphus striatus* (Sars et Boeck MS) = *Trilobites striatus* Sars and Boeck.

Pl. 3, fig. 12—15.

"Tr. striatus Ss. & Bk. Mscr. ist eine dritte Art, welche wahrscheinlich zu derselben Abtheilung wie die zuletzt angeführte gehört, und welche sich kenntlich dadurch auszeichnet, dass die untere Schale des scutum sehr breit und mit dicht auf einander folgenden Streifen versehen ist, deren Anzahl ungefähr doppelt so gross ist, als bei Tr. expansus und Tr. acuminatus. Von dieser Art kennt man nur ein Bruchstück, welches in der Sammlung der Universität aufbewahrt und von Hrr. Sars zu Eger gefunden ist."

Remarks: It has not been possible to find the pygidium which Brøgger (1882, pl. 8, fig. 4) mentions as the type specimen of Boeck. Brøgger established a new variety, *Asaphus striatus* var. *sarsi* Brøgger, which he distinguishes from the "forma typica" or "forme large" as a "forme longue" which also has a greater size and a somewhat smaller number of striæ on the doublure of the pygidium.

In the old collection, where all specimens are marked as *Asaphus striatus*, I have selected as neotype one specimen which fulfills the requirements to the "forma typica". The species is characteristic of the Orthoceras Limestone (3c γ) of the Oslo Region.

Neotype: No. 56257 Pal. Mus. Oslo Coll. (Pl. 3, fig. 12—15).

10. *Nileus armadillo* Dalman, var. *depressa* (Sars et Boeck MS) = *Trilobites depressus* Sars and Boeck.

"Bei Christiania kommt auch ein Trilobit vor, der dem Tr. Armadillo Dalm. sehr nahe steht, Tr. depressus Ss. & Bk. Mscr., welcher aber ausserdem, dass er constant nur etwa halb so gross ist, und indem er auf dem hintern Theile der prominentia einen kleinen Knoten und, wenn er zusammengerollt ist, einen verhältnissmässig flacheren Körper hat, für specifisch verschieden von jenem angesehen werden muss."

Remarks: Brøgger (1882, p. 62) regards this form as a variety of Dalman's species and distinguishes as the variety the small form occurring in the Expansus Shale (3c β). Brøgger (l. c. pl. 7, fig. 6, 6a) figures this form, but the type specimen is lost. Schmidt (1904, p. 68) does not distinguish especially the present variety, but mentions that the Baltic species corresponds to the small form, var. *depressa* described by Brøgger.

In the old collection, numerous specimens are labelled *Tr. depressus*. Most of them, however, belong to the larger typical form occurring in the Opygiocaris Shale. Some of the small specimens from the Expansus Shale are also present, but none of them are very good.

Lectotype: No. 56224 Pal. Mus. Oslo Coll.

(*Trilobites intermedius* Boeck = *Nileus armadillo* Dalman.)

"Dagegen findet sich in Professor Esmarks Sammlung ein Exemplar von einem Trilobite, welcher dem Tr. Armadillo Dalm. mehr ähnelt, aber einen Uebergang zwischen diesem und Tr. lævis zu bilden scheint. Wegen dieser Aehnlichkeit beider möchte er Tr. intermedius zu nennen seyn."

Remarks: No specimen with this name is found in the old collection and with the incomplete description the species or variety has to be discarded.

11. *Nileus armadillo* Dalman, var. *oblongata* (Boeck) = *Trilobites oblongatus* Boeck.

"Eine vierte Trilobitenform, von welcher clypeus mit einem Theile der segmenta auch in der Sammlung des Hrrn. Esmark liegt und welcher zu Eger gefunden ist, steht ebenfalls dem Tr. lævis sehr nahe, ist aber dadurch kenntlich, dass die lobi oculares elongati sind, da sie bei allen übrigen nahestehenden Arten rotundati sind, wie denn auch der ganze Körper verhältnissmässig gestreckter ist, wornach er also Tr. oblongatus genannt werden könnte."

Remarks: Brøgger (1882, p. 64) maintains this form as a variety. He bases his description of one of the old specimens, probably the type specimen of Boeck. The type specimen has not yet been found in the Museum collection.

Lectotype: Specimen figured by Brøgger 1882, Pl. 12, fig. 8.

12. *Symphysurus angustatus* (Sars et Boeck MS) = *Trilobites angustatus* Sars and Boeck.

"In Kalknieren zwischen Christiania und der Kirche von Agers sind Bruchstücke des mittelsten Theiles des clypeus eines Trilobiten gefunden, welcher zu derselben Abtheilung zu gehören scheint, als die zuletzt angeführten. Bei diesem ist die prominentia ziemlich schmal, so dass die lobi oculares einander nahe kommen, und er macht sonach eine eigene besondere Art aus, Tr. angustatus Ss. & Bk. Mscr."

Remarks: This species, so characteristic of the Ceratopyge Limestone (3 a γ), is described by Brøgger (1882, pl. 3, fig. 9, 10) and several other authors. In the illustrations of Brøgger, the palpebral lobes are drawn somewhat too small. The old collection has a number of specimens referred to this species and one of them is selected as a lectotype.

Lectotype: No. 56215 a, Pal. Mus. Oslo Coll.

13. *Olenus attenuatus* (Boeck) = *Trilobites attenuatus* Boeck.

"Unter der Benennung Tr. gibbosus Wahlb. sind zwei verschiedene Arten zusammengemengt, welche bei Andrarum in Schweden vorkommen, deren eine in Magazin for Naturvidenskaberne für 1827 abgebildet ist. Die andere hat weit längere spinas anguli clypei et extremitatum segmentorum nebst einem gestreckteren Körper. Jene scheint die allgemeinste zu seyn, für welche also der Name Tr. gibbosus beibehalten, wogegen die andre Tr. attenuatus genannt werden könnte. Sowohl bei Oslo als in Hadeland i Norwegen kommt ein Trilobit vor, welcher eine prominentia clypei in der Hauptform diesem Theile bei den angeführten schwedischen Arten ähnlich hat, welcher aber einer dritten den vorhergehenden nahestehenden Art zuzugehören scheint. Da jedoch keine vollständige Exemplare gefunden sind ist es am sichersten, ihn in unserem Kataloge als Tr. gibbosus var. aufzuführen."

Remarks: It has not been possible to trace any specimen of this form in the old collection. Westergård (1922, p. 128—129) maintains Boeck's name which was also used by Angelin (1851—1878). Westergård mentions that the Riksmuseum in Stockholm has two old specimens from Andrarum and that they comprise the types of Angelin. Since Boeck's type is lost one of Angelin's specimens has to be chosen as a neotype since the species primarily is based on a Swedish form according to Boeck's description.

14. *Sphærophthalmus alatus* (Boeck) = *Trilobites alatus* Boeck.

Pl. 1, fig. 16, 17.

"Tr. alatus mh. ist eine dem Tr. gibbosus nahestehende Art, welche sowohl in Schweden bei Andrarum, als auch in Norwegen bei Opslo vorkommt, von welcher jedoch noch keine vollständige Exemplare entdeckt sind, da nur der mittlere Theil des clypeus deutlich in dem Stinksteine zu sehen ist, worin er gefunden wird. Allein an diesem Theile bemerkt man, dass die prominentia verhältnissmässig weit schmaler ist, als bei Tr. gibbosus; auch ist die Linie, welche von dem vordersten Theile der prominentia bis an den vordersten Rand des lobus ocularis reicht, nicht eben so gerade hinauswärtsgehend, als bei jenem, sondern bedeutend rückwärts gezogen."

Remarks: Angelin (1851—1878, pl. 26, fig. 9) presented a not very successful reconstruction of the species. Linnarsson (1880, p. 7, pl. 1, fig. 6—10) gave the first detailed description of the species which is so characteristic of the Upper Cambrian of Scandinavia. He says that the species described undoubtedly is identical with Boeck's species. With Brøgger's assistance, he had the opportunity of comparing the Swedish form with the type specimens in the Museum in Oslo. The author also describes a new species *Sphærophthalmus majusculus* (l. c. p. 11, pl. 1, fig. 11, 12) which is said to have a cephalon very similar to that of *S. alatus*, only the fixed cheeks being slightly broader and the glabella a little more narrow in front.

The two species are well described in the monograph by Westergård (1922, p. 165—167). Also this author points out the close relationship and finds that the distinguishing characters — the width of the cheeks and the pleuræ of the pygidium — are subject to considerable variation and thus diminish the difference between the species. The cranidia figured by Westergård (l. c. pl. 13, fig. 20 a—c, 22, 23) have narrow fixed cheeks and thus deviate clearly from the broader cranidia of *S. majusculus* (l. c. pl. 13, fig. 30 a—c, 31, 32). A difference is also noticed in the more trapezoid and less convex glabella.

On examining the old collection in the museum, I found there pieces of limestone containing numerous specimens of *Sphærophthalmus* labelled: *Trilobites alatus*. Some of the specimens (e. g. pl. 1, fig. 16, 17) were especially cleaned and marked, and they apparently represent the types. At first I was alarmed to find that the figured specimen was a rather broad form, at least not of the very narrow type figured by Westergård (l. c. pl. 13, fig. 20 a—c). The glabella on the other hand, is strongly convex in the frontal portion and the outline is more rectangular than in *S. majusculus* Linnarsson. As above mentioned, the Swedish authors have pointed out the variation in the width of fixed cheeks, and I therefore find it correct to select Boeck's specimen as a lectotype. Some other specimens were more narrow and thus show the variation. It is not likely that Linnarsson had some other specimens of Boeck's collection. *S. majusculus* is by Linnarsson (not by Brøgger) only recorded from Andrarum.

Lectotype: No. 56371, Pal. Mus. Oslo Coll. (Pl. 1, fig. 16, 17).

15. *Eurycare latum* (Boeck) = *Trilobites latus* Boeck.

"Tr. Latus mh. zeichnet sich dadurch von Tr. gibbosus aus, dass das Stück zwischen prominentia und lobi oculares beträchtlich breit ist. Ueberdies ist diese Art bedeutend grösser gewesen als Tr. gibbosus, und scheint sich daher dem Tr. spinulosus zu nähern. Nach dem bekannten Theile des clypeus zu schliessen, bilden alle diese Arten, nähmlich Tr. spinulosus, Tr. latus, Tr. attenuatus, Tr. gibbosus und Tr. alatus, ein sehr natürliches Geschlecht, für welches die erwähnte erhöhete Linie zwischen prominentia und lobi oculares eins der Hauptkennzeichen ist. Die anguli clypei sind wahrscheinlich bei allen liberi, d. h. es giebt einen Zwischenraum zwischen spina anguli und dem äussersten Ende des ersten Segments; bei Tr. latus und alatus aber ist der freie Rand vermuthlich sehr vorwärts gezogen, so dass die eigentlichen anguli clypei mehr nach vorne zu kommen stehen, als sonst gewöhnlich bei Trilobiten der Fall ist."

Remarks: This species, which forms the guide-fossil of the Eurycare zone (2c) in the Upper Cambrian, is not well represented in the old collection. The species has been well illustrated and described in later papers by Brøgger (1882), Pehrson (1904), and Westergård (1922). The specimen figured by Brøgger (l. c. pl. 12, fig. 2) evidently is from the old collection. Since this type specimen has not yet been traced in the museum, and the other specimens, cotypes, of the old collections are incomplete, I have decided provisionally not to select a lectotype of this species.

16. *Harpides rugosus* (Sars & Boeck MS) = *Trilobites rugosus* Sars and Boeck.

Pl. 1, fig. 14, 15.

"In einem hellen harten Kalke aus der Umgegend Cristianias, hat Hr. Sars den vordesten Theil eines Trilobiten gefunden, Tr. rugosus Ss. & Bk. Mscr., welcher gewisser Maassen einen Uebergang zwischen den letztangeführten Arten und Tr. Sulzeri Schloth. zu bilden scheint. Die prominentia ist, wie bei diesem, nach vorne zugerundet, und aus dem vordesten Theile entspringen auch, wie bei Tr. gibbosus, die Linien, welche nach den Seiten hinausgehen, was auch der Fall bei Tr. Sulzeri ist. Die Seitenerhöhungen der clypeus, gemeinhin genæ genannt, sind unregelmässig gerunzelt. Da in der Samlung des Hrrn. Professors Nilsson ein Bruchstück eines Trilobiten aufbewahrt wird, welcher von derselben Form wie der hier beschriebene ist, erhellt, wiewohl bisher nur Bruchstücke gefunden worden, welche die vollständige Form des fraglichen Trilobiten nicht angeben können, dennoch so viel, dass er zu einer eigenen bestimmten Art. gehört."

Remarks: Two specimens (pl. 1, fig. 14, 15) of this form were found in the old collection. They illustrate well the structures of the cephalon and show that it is much broader than indicated, after Angelin, in a more recent drawing by Moberg and Segerberg (1906, pl. 5, fig. 1).

Lectotype: No. 20053 Pal. Mus. Oslo Coll. (Pl. 1, fig. 14).

Hypotypoid: No. 20052 Pal. Mus. Oslo Coll. (Pl. 1, fig. 15).

Trinucleus bronni (Sars et Boeck MS) = *Trilobites Bronni* Sars and Boeck.

Pl. 1, fig. 18.

> "Die vierte Form macht vermuthlich eine neue Art aus, Tr. Bronni Ss. & Bk. Mscr., welche sich dadurch auszeichnet, dass der Gürtel um den clypeus nur mit zwei Reihen vertiefte Punkte ausgekerbt ist, wobei die spinæ angulorum lang und nadelförmig sind. Die prominentia ist überdies nie so kugelförmig als bei Tr. tessellatus oder Tr. ornatus."

Remarks: I have previously (Størmer 1930, p. 19) pointed out that this species is identical with *Trinucleus coscinor(rh)inus* Angelin (1851—1878 p. 65 pl. 34, fig. 4) and that the lectotype has to be chosen from among the old cotypes of Boeck.

A closer study of the old specimens leaves no doubt as to the identity of the species. The details of the fringe show the characteristic number of pits. As lectotype is selected a rather small specimen since the larger ones are too fragmentary.

The species is a guide-fossil of the upper sandy transition layers between the Ogygiocaris Shale (4 a α) and the Ampyx Limestone (4 a β) in the Oslo Region.

Lectotype: No. 61752 Pal. Mus. Oslo. Coll. (Pl. 1, fig. 18).

List of Norwegian Trilobite Species and Varieties described by Esmark, Sars, Boeck and Angelin.

1. *Proetus asellus* (Esmark) = *Trilobites asellus*, Esmark 1833.
2. *Phacops elliptifrons* (Esmark) = *Trilobites elliptifrons*, Esmark 1833.
3. *Hemisphærocoryphe sphæricus* (Esmark) = *Trilobites sphæricus*, Esmark 1833.
4. *Cybele dentata* (Esmark) = *Trilobites dentatus*, Esmark 1833.
5. *Ceratopyge forficula* (Sars) = *Olenus forficula*, Sars 1835.
6. *Shumardia pusilla* (Sars) = *Battus pusillus*, Sars 1835.
7. *Lonchodomas rostratus* (Sars) = *Ampyx rostratus*, Sars 1835.
8. *Ampyx mammilatus* Sars = *Ampyx mammilatus*, Sars 1835.
9. *Chasmops conicophthalma* (Sars & Boeck MS) = *Trilobites conicophthalmus*, Sars and Boeck MS 1829 — Boeck 1838.
10. *Acidaspis armata* (Sars & Boeck MS) = *Trilobites armatus*, Sars and Boeck MS 1829 — Boeck 1838.
11. *Asaphus striatus* (Sars & Boeck MS) = *Trilobites striatus*, Sars and Boeck MS 1829 — Boeck 1838.
12. *Nileus armadillo* Dalm. var. *depressa* (Sars & Boeck MS) = *Trilobites depressus*, Sars and Boeck MS 1829 — Boeck 1838.
13. *Symphysurus angustatus* (Sars & Boeck MS) = *Trilobites angustatus*, Sars and Boeck MS 1829 — Boeck 1838.
14. *Harpides rugosus* (Sars & Boeck MS) = *Trilobites rugosus*, Sars and Boeck MS 1829 — Boeck 1838.
15. *Trinucleus bronni* (Sars & Boeck MS) = *Trilobites Bronni*, Sars and Boeck MS 1829 — Boeck 1838.
16. *Nileus armadillo* Dalm. var. *oblongata* (Boeck) = *Trilobites oblongatus*, Boeck 1838.
17. *Chasmops extensa* (Boeck) = *Trilobites extensus*, Boeck 1838.
18. *Apatocephalus serratus* (Boeck) = *Trilobites serratus*, Boeck 1838.
19. *Asaphus raniceps* Dalm. var. *acuminatus* (Boeck) = *Trilobites acuminatus*, Boeck 1838.
20. *Megalaspis limbata* (Boeck) = *Trilobites limbatus*, Boeck 1838.
21. *Olenus attenuatus* (Boeck) = *Trilobites attenuatus*, Boeck 1838.
22. *Sphærophthalmus alatus* (Boeck) = *Trilobites alatus*, Boeck 1838.
23. *Eurycare latum* (Boeck) = *Trilobites latus*, Boeck 1838.
24. *Ampyx costatus* (Boeck MS) = *Ampyx costatus*, Boeck MS?, Angelin 1854.
25. *Dicellocephalina dicræura* (Angelin) = *Centropleura? dicræura*, Angelin 1854.
26. ? *Encrinurus caudatus* (Angelin) = *Cryptonymus caudatus*, Angelin 1854.
27. *Trimerolichas? norvegicus* (Angelin) = *Lichas norvegicus*, Angelin 1854.

28. *Ampyx? aculeatus* Angelin = *Ampyx? aculeatus*, Angelin 1854.
29. *Lonchodomas affinis* Angelin, Angelin 1854.
30. *Lonchodomas crassirostris* Angelin, Angelin 1854.
31. *Lonchodomas domatus* Angelin, Angelin 1854.
32. *Illænus oblongatus* (Angelin) = *Rhodope? oblongata*, Angelin 1854.
33. *Telephus bicuspis* Angelin, Angelin 1854.
34. *Telephus granulatus* Angelin, Angelin 1854.
35. *Trinucleus bucculentus* Angelin, Angelin 1854.
36. *Trinucleus foveolatus* Angelin, Angelin 1854.
37. *Cryptolithus discors* (Angelin) = *Trinucleus discors*, Angelin 1854.
38. *Ogygiocaris dilatata* (Brünn.) var. *sarsi* Angelin, Angelin 1878.
39. *Ogygiocaris dilatata* (Brünn.) var. *strømi* Angelin, Angelin 1878.

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Printed February, 1940.

PLATES

REPRODUCED PHOTOGRAPHS

NOT RETOUCHED. SPECIMENS WHITENED EXCEPT
IN PL. 1, FIG. 3, 4, 11; PL. 3, FIG. 5

Pl. 1.

Fig. 1. *Proetus asellus* (Esmark). 2 ×. Nearly complete specimen. Trinucleus Shale (4 a α)? Trosvigen, Brevig. Lectotype, No. 56442 Pal. Mus. Oslo Coll.

» 2. *Phacops elliptifrons* (Esmark). 2 ×. Enrolled specimen. Striclandia zone (6 c), Malmøy. Neotype, No. 20966 Pal. Mus. Oslo Coll.

» 3. The same.

» 4. The pygidium of the same specimen.

» 5. *Cybele dentata* (Esmark). 2 ×. Impression of pygidium. Ogygiocaris-Ampyx zones (4 a)? The Royal Palace Oslo. Lectotype, No. 56161 Pal. Mus. Oslo Coll.

» 6. *Hemisphærocoryphe sphæricus* (Esmark). 2 ×. Cranidium. Ampyx-Chasmops zones (4 a—4 b)? Løken, Bygdøy. Neotype, No. 61747 Pal. Mus. Oslo Coll.

» 7. The same in lateral view.

» 8. *Ceratopyge forficula* (Sars). 2 ×. Impression of free cheek. Ceratopyge Shale (3 a β), Ruseløkken Oslo. Hypotypoid, No. 56197 b, Pal. Mus. Oslo Coll.

» 9. Cranidium. 2 ×. The same hor. and loc. Lectotype, No. 42690 a Pal. Mus. Oslo Coll.

» 10. Two pygidiæ. 2 ×. The same hor. and loc. Hypotypoid, No. 42690 b Pal. Mus. Oslo Coll.

» 11. Pygidium. 2 ×. The same hor. and loc. Hypotypoid, No. 56199 Pal. Mus. Oslo Coll.

» 12. *Acidaspis armata* (Sars & Boeck MS). 2 ×. Pygidium. Hor. and loc. uncertain. (Probably Trinucleus Shale, Brevik.) Lectotype, No. 56150 Pal. Mus. Oslo Coll.

» 13. *Shumardia pusilla* (Sars). 2 ×. Cephalon. Ceratopyge Shale (3 a β), Sophienberg near Drammensveien, = Ruseløkken, Oslo. Lectotype, No. 56420 Pal. Mus. Oslo Coll.

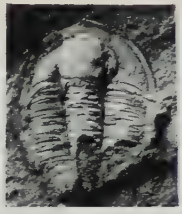
» 14. *Harpides rugosus* (Sars & Boeck MS). 1 ×. Ante-median portion of cephalon. Ceratopyge Limestone (3 a γ), Oslo. Lectotype, No. 20053 Pal. Mus. Oslo Coll.

» 15. Posterior portion of cephalon. 1 ×. The same hor. and loc. Hypotypoid, No. 20052 Pal. Mus. Oslo Coll.

» 16. *Sphærophthalmus alatus* (Boeck). 2 ×. Ceanidium. Peltura-zone (2 d), Alum-quarry, Gamlebyen, Oslo. Lectotype, No. 56371 Pal. Mus. Oslo Coll.

» 17. The same in lateral view.

» 18. *Trinucleus bronni* (Sars & Boeck MS). 2 ×. Cephalon. Ogygiocaris —Ampyx zones (4 a), Wraatz's Løkke, Oslo. Lectotype, No. 61752 Pal. Mus. Oslo Coll.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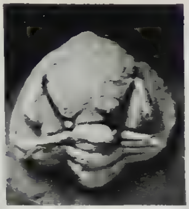
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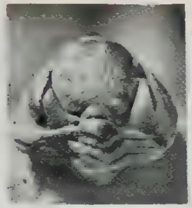
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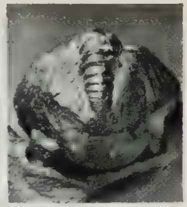
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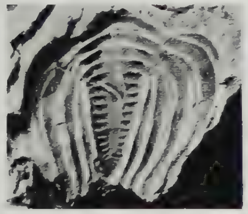
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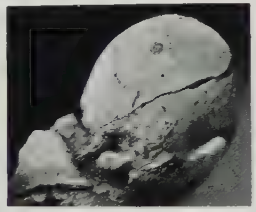
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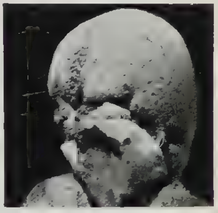
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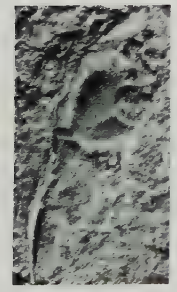
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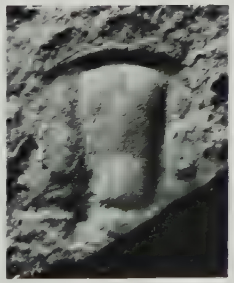
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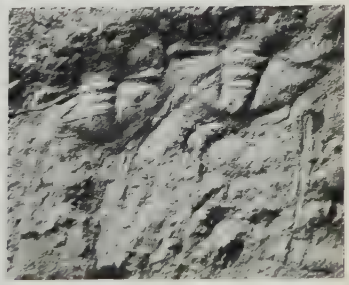
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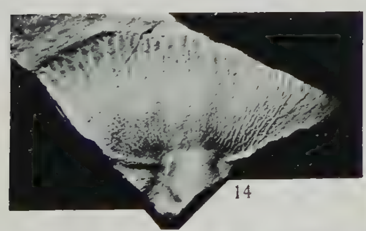
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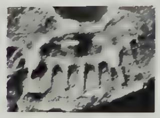
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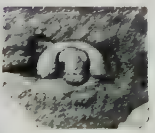
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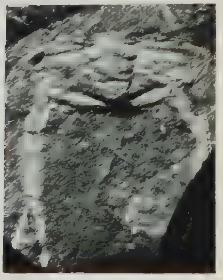
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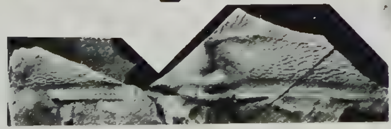
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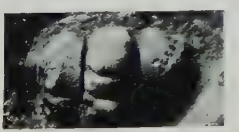
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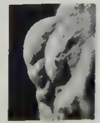
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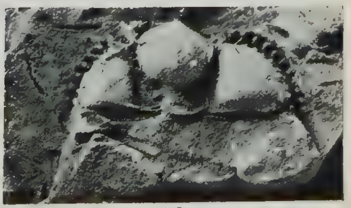
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Pl. 2.

Fig. 1. *Lonchodomas rostratus* (Sars). 2 ×. Cranidium. Ampyx Limestone (4 a β), Bygdøy. Hypotypoid, No. 61749 Pal. Mus. Oslo Coll.

» 2. Nearly complete specimen. 2 ×. The same hor., Huk, Bygdøy. Lectotype, No. 56407 Pal. Mus. Oslo Coll.

» 3. Cranidium with frontal spine. 2 ×. The same hor. and loc. Hypotypoid, No. 61750 Pal. Mus. Oslo Coll.

» 4. Pygidium. 2 ×. The same hor., Hjortnestangen, Oslo. Paratypoid, No. 56404 Pal. Mus. Oslo Coll.

» 5. *Ampyx mammilatus* Sars. $^4/_3$ ×. Cranidium, Ogygiocaris Shale (4 a α), Hjortnestangen, Oslo. Hypotypoid, No. 61749 Pal. Mus. Oslo Coll.

» 6. The same in lateral view.

» 7. Pygidium. $^4/_3$ ×. The same hor. and loc. Paratypoid, No. 56393 Pal. Mus. Oslo Coll.

» 8. Cranidium. $^4/_3$ ×. The same hor. and loc. Lectotype, No. 56403 Pal. Mus. Oslo Coll.

» 9. The same in lateral view.

» 10. Cranidium, large specimen. $^4/_3$ ×. The same hor. and loc. Hypotypoid, No. 56401 Pal. Mus. Oslo Coll.

» 11. The same in lateral view.

» 12. Pygidium and cranidium. 2 ×. The same hor. and loc. Hypotypoid, No. 56396 Pal. Mus. Oslo Coll.

» 13. *Ampyx costatus* (Boeck MS). $^4/_3$ ×. Cranidium. Ampyx Limestone (4 a β)?, Bygdøy. Lectotype, No. 56399 Pal. Mus. Oslo Coll.

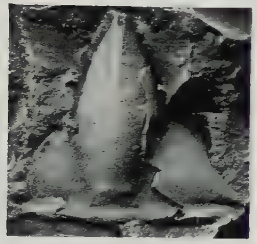
» 14. The same in lateral view.

» 15. The same in frontal view.

» 16. Cranidium. $^4/_3$ ×. The same hor.? "Natmandsboligen", Aker. Hypotypoid, No. 56404 Pal. Mus. Oslo Coll.

» 17. The same in lateral view.

» 18. Pygidium. $^4/_3$ ×. The same hor.? Hjortnestangen, Oslo. Hypotypoid, No. 56405 Pal. Mus. Oslo Coll.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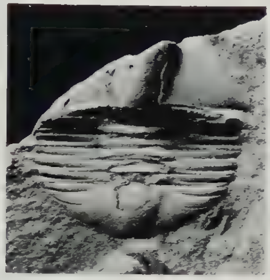
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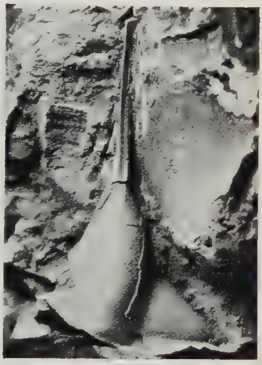
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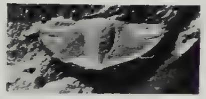
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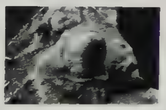
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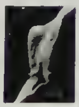
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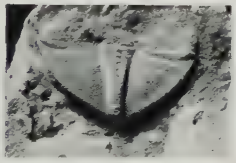
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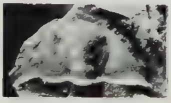
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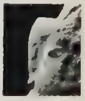
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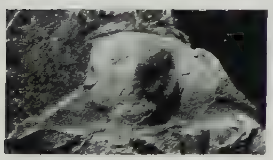
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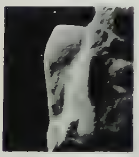
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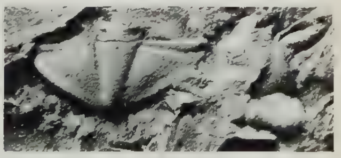
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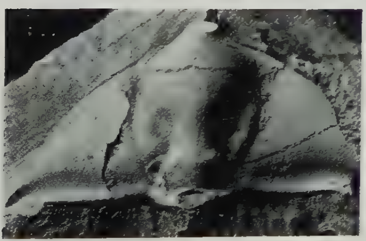
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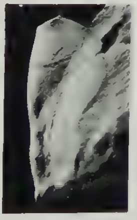
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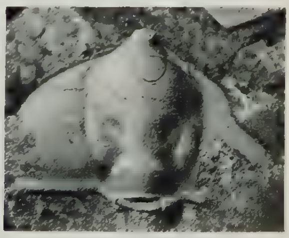
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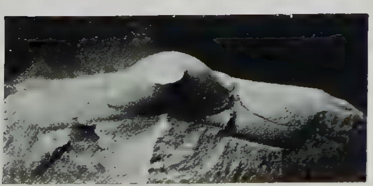
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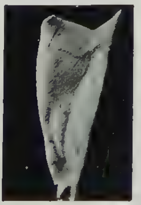
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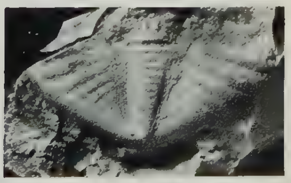
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Pl. 3.

Fig. 1. *Chasmops conicophthalma* (Sars & Boeck MS). 1 ×. Cephalon. Chasmops-zones (4 b α—β)? Hjortnestangen, Oslo. Hypotypoid, No. 61750 Pal. Mus. Oslo Coll.

» 2. The same in lateral view.

» 3. Cephalon. 1 ×. The same hor., The Royal Palace, Oslo. Lectotype, No. 56148 Pal. Mus. Oslo Coll.

» 4. The same in frontal view.

» 5. Impression of nearly complete specimen. 1 ×. The same hor. loc. unknown. Hypotypoid, No. 56154 Pal. Mus. Oslo Coll.

» 6. Pygidium. 1 ×. The same hor. Huk, Bygdøy. Hypotypoid, No. 56153 a Pal. Mus. Oslo Coll.

» 7. *Chasmops extensa* (Boeck). 1 ×. Cephalon without genal spines. Chasmops-zones (4b γ—δ)? Gåsøykalven, Bærum. Lectotype, No. 56167 Pal. Mus. Oslo Coll.

» 8. The same in lateral view.

» 9. The same in frontal view.

» 10. Pygidium. 1 ×. The same hor. and loc. Hypotypoid, No. 56165 e Pal. Mus. Oslo Coll.

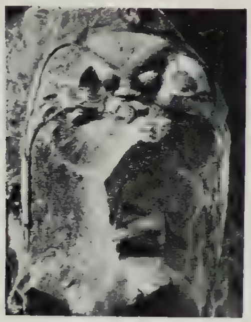
» 11. The same in lateral view.

» 12. *Asaphus striatus* (Sars & Boeck MS). 1 ×. Cephalon of enrolled specimen. Orthoceras Limestone (3 c γ), Huk, Bygdøy. Lectotype, No. 56257 Pal. Mus. Oslo Coll.

» 13. The same in lateral view.

» 14. The same in frontal view.

» 15. The pygidium of the same specimen.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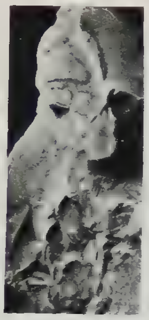
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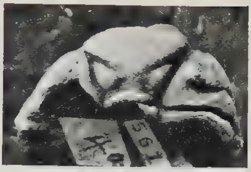
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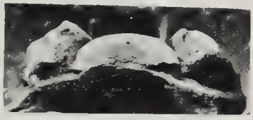
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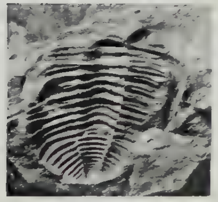
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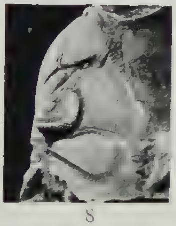
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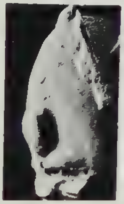
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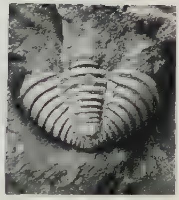
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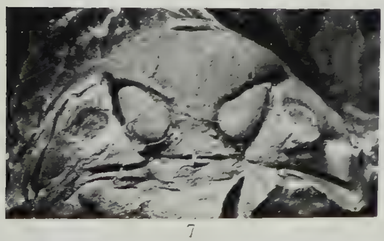
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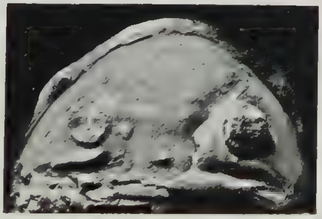
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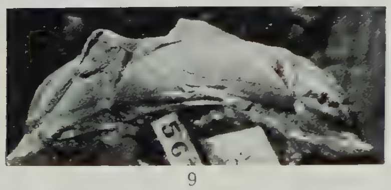
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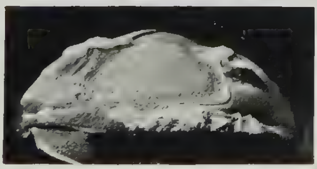
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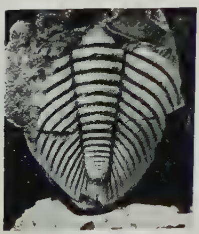
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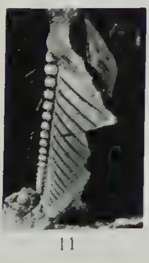
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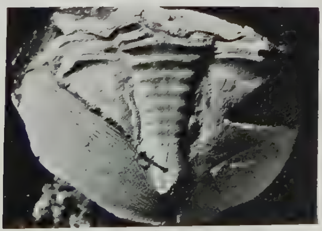
15

NORSK GEOLOGISK FORENING

MØTE TIRSDAG 12. DESEMBER 1939

Til stede 18 medlemmer og 9 gjester.

Innvalg.

224. Dr. philos. EINAR JENSEN, Kjemisk institutt, Blindern.
Etter forslag av A. Bugge og O. A. Broch.

Foredrag.

KAARE MÜNSTER STRØM: „Geologisk kart i svart og hvitt.“ Demonstrasjon med lysbilder.

G. Holmsen og foredragsholderen uttalte seg.

NIELS-HENRIK KOLDERUP: „Bergensbuenes geologi.“

Foredraget var et utdrag av et arbeide av C. F. Kolderup og foredragsholderen som vil bli trykt i Bergens museums skrifter nr. 19.

Etter foredraget kom det uttalelser av A. Bugge, Isachsen, Størmer, Rosendahl, Holtedahl og foredragsholderen. En rekke av medlemmenes damer deltok i aftensmåltidet. Ved kaffeen viste A. Heintz en film fra siste sommers Spitsbergenekspedisjon.

GENERALFORSAMLING OG MØTE TORSDAG 8. FEBRUAR 1940

Til stede 19 medlemmer og 13 gjester.

Generalforsamling.

Årsmelding for 1939.

Siden forrige generalforsamling er det utgått 2 medlemmer:

ALVAR HÖGBOM, død 27. august 1939,

OLAF N. ROVE, utmeldt.

I samme tidsrom er det innvalt ett nytt medlem:

224. EINAR JENSEN. Universitetets kjemiske institut. Blindern. 12. des. 1939.

Dessuten er de tidligere medlemmer nr. 62 J. Braastad og nr. 122 A. Gurholt gjeninnvalt.

Medlemstallet er nu 131, hvorav 1 æresmedlem, 56 livsvarige og 74 årsbetalende.

Det er holdt 6 ordinære og 1 ekstraordinært møte, sistnevnte sammen med Norsk botanisk forening. Et av de ordinære møter var fellesmøte sammen med Norsk ingeniørforening, Bergingeniørenes avdeling. Det samlede frammøte på møtene var omkring 280.

Av tidsskriftet er i året utkommet bd. 18 h. 4 og bd. 19 h. 1—3. Bd. 19 h. 4 er ferdigtrykt.

Regnskap for 1939.

Inntekt.

Beholdning overført fra 1938:		
Ordinære budgett	kr. 1 881,04	
Renter fra livsvarige medlemmers fond	„ 978,99	
		kr. 2 860,03
Medlemskontingent for 1938 og 1939		„ 720,00
Renter fra livsvarige medlemmers fond for 1939		„ 189,44
Tilskot fra staten		„ 400,00
Tilskot fra Sulitelmafondet		„ 3 250,00
Ekstra trykningstilskot:		
Fra Kongsberg sølvverk til E. Jensen: Sølvet på Kongsberg, bd. 19 h. 1	kr. 1 000,00	
Fra Nansenfondet til L. Størmer: Studies on trilobite morphology, bd. 19 h. 2—3	„ 1 500,00	
Fra Nansenfondet til O. T. Grønlie: Traces of the ice ages, bd. 20 h. 1—2	„ 800,00	
Fra Nansenfondet til Jens Bugge: Geol. and petr. invest., bd. 20 h. 1—2	„ 500,00	
		„ 3 800,00
Abonnement og salg av tidsskriftet ved A. W. Brøggers boktrykkeri 1930—1937		„ 1 427,50
Abonnement og salg av tidsskriftet 1939		„ 682,63
Renter av bankinnskot 1939		„ 22,89
		kr. 13 352,49

Utgift.

Tidsskriftet:			
Trykking bd. 15, rest	kr. 407,03		
— bd. 16, rest	„ 5,00		
— bd. 17 h. 4	„ 2 488,14		
— bd. 18	„ 6 450,89		
Korrektur bd. 19	„ 19,50		
		kr. 9 370,56	Overføres

Overført		kr. 9 370,56	
Klisjeer bd. 15 rest	kr. 15,00		
— bd. 18 rest	„ 429,82		
— bd. 19	„ 1 298,84		
		„ 1 743,66	
			kr. 11 114,22
Arbeidshjelp, porto, skrivesaker			„ 576,20
Møter, representasjon			„ 275,98
Rabatt på salg av tidsskriftet			„ 163,83
Reuschmedaljen			„ 17,40
Forvaltning av statsobl., livsvarige medlemmers fond.			„ 5,00
Overført til 1940			„ 1 199,86
			kr. 13 352,49

Status pr. $^{2}/_{1}$ 1940.

Livsvarige medlemmers fond. Urørlig kapital.			
Statsobligasjoner	kr. 3 500,00		
Bankinnskot	„ 1 065,00		
		kr. 4 565,00	
Utestående medlemskontingent			kr. 240,00
Beholdning			„ 1 199,86
			kr. 1 439,86

Regnskapet var revidert av S. Føyn og H. H. Smith og ble godkjent.

Valg av styre for 1940.

Formann	L. Størmer
Redaktør	H. Rosendahl
Sekretær	T. Strand
Styremedlemmer	J. Helverschou F. Isachsen
Varamann	C. W. Carstens

Revisorene, H. H. Smith og S. Føyn, ble gjenvalt.

Til medlemmer av Reuschmedaljekomiteen for 1940 ble valt O. A. Broch og G. Horn.

Til medlemmer av Sulitelmafondets råd for 1940—42 ble valt C. Bugge og C. W. Carstens med S. Foslie som varamann.

Regnskapsførerens løn for 1940, kr. 200,00, ble godkjent.

Møte.

Til møtet var innbudt Bergingeniørforeningen og Kartografisk forening. Den svenske geolog Erland Grip fra Boliden var til stede.

Foredrag.

Cand. oecon. Vilhelm Skappel, professor Olaf Holtedahl og statsgeolog Olaf Anton Broch: „Luftkartleggingen i geologiens tjeneste“. Skappel redegjorde for de luftfotogrammetriske kartleggingsmetoder og framhevet deres fremragende yteevne for topografisk, geologisk og økonomisk kartlegging. Holtedahl og Broch viste talrike eksempler på hvordan luftfotografier er til den største nytte for geologene. I tilslutning til foredragene viste ingeniør Hollan Hagen en film om fotogrammetrisk kartlegging,

I ordskiftet etter foredragene deltok Helverschou, C. Bugge, Grip, Rosenlund og V. Skappel.

F. Isachsen viste et stykke Kvædfjordkul fra Karmøy. En meddelelse om funnet vil bli trykt i „Naturen“.

MØTE TORSDAG 14. MARS 1940

Til stede 19 medlemmer og 6 gjester.

Formannen innledet møtet med å minne om professor W. C. Brøggers innsats for foreningen og hans banebrytende arbeide for geologien i vårt land. Forsamlingen hedret den avdødes minne ved å reise seg.

Foredrag:

W. C. Brøgger som forsker og lærer.
V. M. Goldschmidt: Brøgger som mineralog og petrograf.
O. Holtedahl: Brøgger som paleontolog og geolog.

Referat av foredragene vil bli trykt i Videnskaps-Akademiets årbok. Formannen takket foredragsholderne.

Ved aftensbordet talte K. O. Bjørlykke og C. Bugge om foreningens stiftelse og første historie, i anledning av at det i år er 35 år siden foreningens offisielle stiftelse, mens den geologiske klubs historie går 50 år tilbake. Dessuten var det taler av formannen, Isachsen og Münster Strøm.

Trykt 21. oktober 1940.

Ms. mott. febr. 28, 1940

ET PROFIL GJENNEM OGYGIASKIFER OG AMPYXKALK PÅ TØRTBERG, FROGNER VED OSLO

AV

HANS-FREDRIK GRORUD

MED 2 TEKSTFIGURER

Innledning.

I sitt arbeide „Geologisk kart over øerne ved Kristiania“ skriver prof. W. C. Brøgger om hovedavdelingene 4 a—4 d i den fossilførende lagrekke i Oslotrakten. Fra sonene 4 a α—4 b α nevnes bl. a. trilobittene *Lonchodomas rostratus* (Sars), *Asaphus platyurus* Ang., *Ogygiocaris dilatata* (Brünn.), *Trinucleus bronni* (Sars & Boeck MS) (= *coscinorhinus* Ang.), *Chasmops conicophthalma* (Sars & Boeck MS). Ved siden av forskjellige arter av graptolitter anføres *Leptæna* og *Orthis*-arter, foruten echinodermer og regulære orthocerer.

På Tørtberg har jeg funnet et profil hvor nettop disse avdelinger med de samme fossiler, er blottet. Jeg har da søkt å finne de forskjellige arters vertikale utbredelse, som angitt på tabellen. For å opnå dette har jeg tatt for mig hver meter av profilet, og avmerket de arter som var å finne eftersom jeg samlet opover. Det kan naturligvis ikke trekkes en helt skarp grense for en arts utbredelse, men jeg har så nøie som mulig avsatt det område hvor den forekommer. Av nogen arter er det bare funnet et eneste fossil, og navnet på denne er derfor på profiloversikten ikke forsynt med nogen klammer som angir større utbredelse.

De funne arter er stort sett de samme som prof. Brøgger nevner fra disse lag. De bemerkninger han har gjort om mengden av artene i de forskjellige soner stemmer også. Det er den *forholdsvise* utbredelse av artene som her skal pointeres.

Jeg vil til slutt få takke dr. L. Størmer og konservator A. Heintz for den elskverdighet og hjelpsomhet de har ydet mig under arbeidet. Fossilmaterialet oppbevares i Paleontologisk Museum Oslo.

Beskrivelse av lagene.

På Tørtberg ved Frogner har man i de senere år utført sprengningsarbeider i forbindelse med Vigelandsanlegget. Ved disse arbeider er fjell-lagene blottet slik at den fossile fauna lett kan studeres. Dessuten har forvitringen fått arbeide lenge nok på bruddflatene, så at fossilene er passe utvitret. Lagenes gjennemsnittlige fall er 60° mot NNV.

Lagene består i forvitret tilstand overalt av en lett smuldrende, gråbrun skifer. I de underste lag finnes ikke kalkboller, og bruddflatene har her et rustrødt forvitringsbelegg. Enkelte tynne, sammenhengende sandstenslag forekommer. Kalkbollene optrer først 18 m opp, og bebuder begynnelsen av avdelingen 4 a β, altså Ampyxkalken, hvilket stemmer med fossilfaunaen. Samtidig med dette forsvinner det rustrøde belegg, og lagene får i det hele tatt en litt fastere karakter. Knollene opptrer med nogenlunde jevn tetthet like opp til profilets øverste del (4 b α), hvor lagenes farve går mere over i det sortbrune.

Fossilene og deres opptreden i lagene.

Før beskrivelsen av faunaen i de forskjellige lag, vil det være nyttig å kaste et blikk på de arter som forekommer gjennem hele profilet. Brachiopodene er rikest representert ved *Plectambonites*(?) og *Orthis*-arter, og forekommer hyppigst i de øverste 30 m. I 4 b α finnes ansamlinger av små brachiopoder, slik som prof. Brøgger omtaler i sitt arbeide over øene ved Kristiania. En annen brachiopode, *Obolus* sp. finnes i de underste 20 m. *Lonchodomas rostratus* (Sars) finnes mest i begynnelsen og slutten av avdelingen 4 a β. Det finnes både hode- og haleskjold.

I de underste 4 m av profilet dominerer *Trinucleus foveolatus* Ang. Eksemplarene av denne art er bra oppbevart, så det perforerte skall tydelig kan studeres. Det er for det meste hodeskjold som finnes. *Ogygiocaris dilatata* (Brünn.) forekommer også hyppig, men nesten bare haleskjold. Av andre arter har jeg funnet: *Telephus granulatus* Ang., *Glyptocystis* cf. *leuchtenbergi* Ang. (Beskrevet av Angelin fra Hovinsholm, Helgøya) og *Diplograptus* sp.

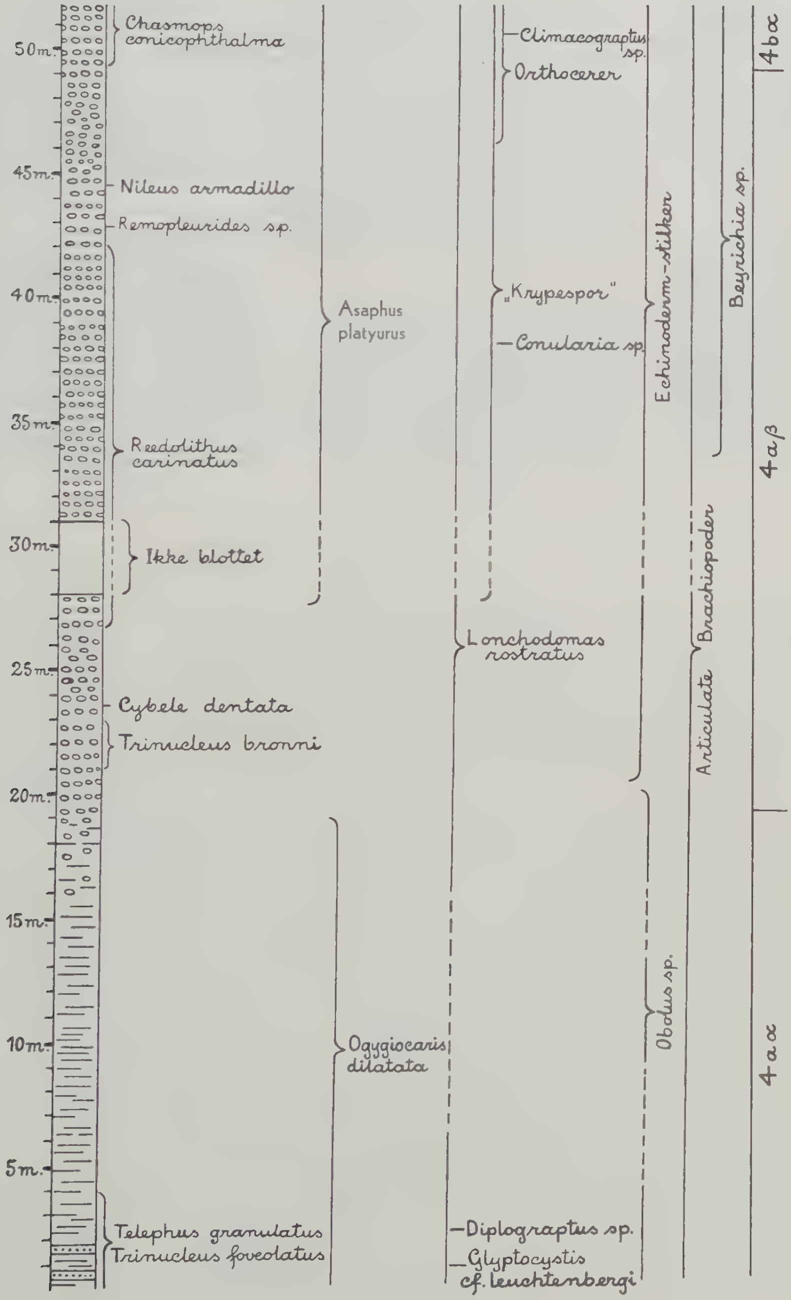
50m.
45m.
40m.
35m.
30m.
25m.
20m.
15m.
10m.
5m.
Chasmops conicophthalma
Nileus armadillo
Remopleurides sp.
Reedolithus carinatus
Ikke blottet
Cybele dentata
Trinucleus bronni
Telephus granulatus
Trinucleus foveolatus
Asaphus platyurus
Ogygiocaris dilatata
Climacograptus sp.
Orthocerer
„Krypespor"
Conularia sp.
Lonchodomas rostratus
Diplograptus sp.
Glyptocystis cf. leuchtenbergi
Echinoderm-stilker
Obolus sp.
Articulate Brachiopoder
Beyrichia sp.
4bα
4aβ
4aα

Fig. 1.

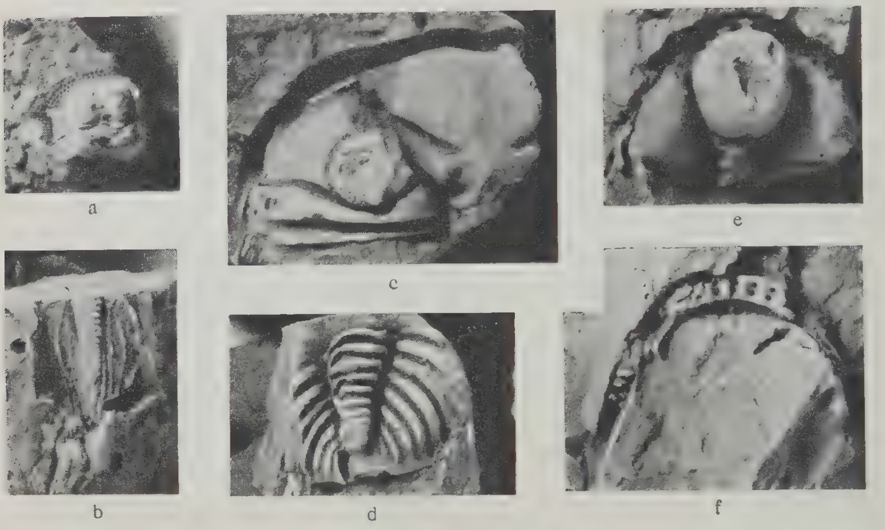

Fig. 2. Fossiler fra Tørtberg. Forstørret 2,8 ×.

Den neste del av profilet, op til 21 m, har relativt få fossiler. *Ogygiocaris dilatata* (Brünn.) er nesten den eneste art som forekommer. Omtrent ved 21 m opptrer imidlertid et forholdsvis tynt, men ganske rikt lag med *Trinucleus bronni* (Sars & Boeck MS) (Fig. 2 e). Det eiendommelige ved denne er at den underste del av bremmen rundt hodeskjoldet ikke som vanlig har *en* men *to* rekker av huller (Fig. 2 f). 2—3 m ovenfor finnes *Cybele dentata* (Esmark) (Fig. 2 b). I disse lag begynner også enkelte echinoderm-stilker å vise sig. De forekommer jevnt gjennem hele resten av profilet.

Den neste ansamling av fossiler består av *Reedolithus carinatus* (Ang.) og varer fra 27 m til omtrent 43 m. Her begynner også *Asaphus platyurus* Ang. å opptre i mengder. Likedan sees enkelte krypespor, samt *Beyrichia* sp. (?). Lenger opp kommer *Conularia* sp., *Remopleurides* sp. og *Nileus armadillo* Dalm.

Enkelte få bruddstykker av regulære orthocerer opptrer like i overgangen til 4 b α, hvor *Chasmops conicophthalma* (Sars & Boeck MS) dominerer. Denne siste art forekommer på en merkelig måte klattevis spredt utover i lagene. Det er funnet både hode- og haleskjold, som er relativt bra opbevart (Fig. 2, c, d).

Trykt 2. november 1940.

Ms. rec. Mars 1, 1940.

DICTYONEMA SHALES OUTSIDE THE OSLO REGION

BY

LEIF STØRMER

WITH 1 PLATE

Abstract: The graptolite *Dictyonema flabelliforme* (Eichw.) has been recorded from Hardangervidda, Holtålen near Røros and Snertingdal north of Gjøvik. The present description of these finds with the associating faunas shows that the occurring species and varieties belong to the Dictyonema Shale (2 e) at the base of the Ordovician.

Introduction.

Fossil occurrences in the metamorphic sediments outside the Oslo Region are known in a considerable number of cases. Besides the more fossiliferous beds of the Bergen and Trondheim Regions, certain singular occurrences such as Hardangervidda, Otta, Smøla, Hitra, Kjølhaugene and others, have been able to elucidate both stratigraphical and tectonic features of great importance. In such cases, however, it is necessary to carry out a detailed and accurate determination of the often badly preserved fossils.

Prof. Dr. Th. Vogt kindly invited me to describe the specimens of *Dictyonema* which he had collected at Holtålen in the Trondheim Region in 1937. The fossil locality was discovered in 1888 by the late Prof. Dr. J. H. L. Vogt and his collection had not been studied in details. Species of the genus *Dictyonema* are not restricted to the characteristic Dictyonema Shale (2 e) at the base of the Ordovician, but might occur even in the Silurian and here partly in abundance. The typical Dictyonema Shale is, however, of particular importance in forming a well marked guide zone at the base of the Ordovician over wide areas of the Northern hemisphere.

Examining the material from Holtålen, I found it necessary for comparison, also to study briefly the faunas of the other Norwegian occurrences of *Dictyonema*. The Oslo Region apparently presents a very complete development of the shale with *Dictyonema flabelliforme*.

It is possible to distinguish several different varieties of the guide fossil and these varieties are characteristic of distinct subzones just as in Great Britain (Bulman 1927—1928). Already in 1907 Fearnsides pointed out the presence of several different varieties of the species in different layers of the Dictyonema Shale at Krekling, Eiker in Norway. Present studies which I have made of the sections through the Dictyonema Shale at Vækerø and Bygdøy Sjøbad near Oslo, have shown that we might distinguish at least 4 subzones. The subzones are distinguished by different varieties of *Dictyonema flabelliforme* just as in Great Britain:

2 e δ	*Dictyonema*	*flabelliforme*	*anglica* Bulman
2 e γ	—	—	*norvegica* (Kjerulf)
2 e β	—	—	forma *typica* Brøgger
2 e α	—	—	*sociale* (Salter)

The zone 2 e β with *D. f.* forma *typica* is most commonly found and seems to have the greatest thickness.

Outside the Oslo Region the graptolite *Dictyonema* has been found at Holtålen in the Trondheim Region, in two localities on the mountain plateau Hardangervidda and in one occurrence in Snertingdal north of Gjøvik. I have studied these faunas more in detail and the present paper gives descriptions of the species and varieties occurring in these Dictyonema Shales outside the Oslo Region.

Holtålen (Haltdal).

In 1888 J. H. L. Vogt (1889) discovered specimens of *Dictyonema* in a black shale at Nordaunevoll, Holtålen, north of Røros. He demonstrated the find in the Academy of Science in Oslo (Kristiania) and the occurrence is mentioned by later authors such as Carstens (1920) and Kiær (1932). Carstens also collected some specimens, one of which is preserved in the Collections of the Palaeontological Museum which also has the original collection of J. H. L. Vogt. The following description is, however, largely based on the more complete collection made by Th. Vogt in 1937. The fossils belong to Norges Tekniske Høgskole in Trondheim and the occurrence is described by Th. Vogt (1940) in an article preceding this in the same periodical.

Dictyonema flabelliforme (Eichwald) var. *sociale* (Salter).

Pl. fig. 6—8.

Preservation. The fossils are preserved in a black alum shale which in weathered state has a greyish colour. The shale has been subject to jointing leaving only elongate, narrow pieces to be obtained. The shape of the fossil specimens indicates that the shale has been compressed at a more or less right angle to the main jointing. The ratio width : length of the *Dictyonema*-colonies is about 1:1.5 when preserved at right angle to the jointing, and about 1:2.7 when preserved parallel to it.

The fossils are not well preserved. The branches (stipes) of the colonies (rhabdosomes) are visible especially in slightly weathered specimens such as in fig. 6 and 8 of the plate. Only in a few cases the cross-bars (dissepements) of the stipes are visible. The preservation of the graptolites as glistening films, such as in the shales of the Oslo Region, is only indicated in some specimens such as the one shown in fig. 7 of the plate.

Description. The shape of the rhabdosome is narrow vasiform with the sides becoming almost parallel in the distal portion. The ratio width : length, apart from the deformation due to preservation, seems to be 1:2.1 in average. The stipes are very fine and close set. In the narrow rhabdosomes more than 20 has been counted in 10 mm, but this might be due to the preservation of both sides of a funnel-shaped colony. The average number of stipes in 10 mm is 14—16. The dissepements are not distinct, but seem to be close set with 10 or more in 10 mm. The cells are not distinguishable.

Relationship. The described form corresponds to the descriptions of *Dictyonema flabelliforme sociale* (Salter). Both the shape of the rhabdosome and the number of dissepements are the same while the number of stipes is somewhat greater than in the typical specimens described by Bulman (1927—1928).

The probable presence of *Dictyonema flabelliforme sociale* suggests that the Røros Shale of Holtålen belongs to the basal part of the Dictyonema Shale (2e α) at the very base of the Ordovician.

Holberget, Hardangervidda.

In 1859 Tellef Dahl (1861, p. 170) discovered *Dictyonema flabelliforme* in phyllitic shales at Holberget on the plateau Hardangervidda about 100 km OSO of Bergen. The fossils were figured by Kjerulf (1865, fig. 2, 3) who established a new species now regarded as a special variety *D. f. norvegica* (Kjerulf). The description of the new form was based on specimens from Holberget and Tøien, Oslo. (On account of preservation it seems natural to choose a lectotype among specimens from Tøien.) Brøgger (1882, p. 36) mentions the specimens of Holberget in his detailed description of the forma *typica* of the species. He includes the specimens in the forma *typica*, but states that transition formes between forma *typica* and var. *norvegica* occur. Brøgger (1893, p. 15) made new collections at Holberget and succeeded in finding the fossiliferous bed which had not previously been traced.

Additional material was collected by Rekstad (1903, p. 21). Besides graptolite specimens he found fragmentary brachiopods (see below). It is possible that these fragmentary brachiopods are identical with badly preserved fossils, found at a somewhat lower level, among which he ment to trace remains of trilobites (Asaphidae).

Dictyonema flabelliforme (Eichwald) var. *norvegica* (Kjerulf).

Pl. fig. 1, 2.

Dictyonema norvegicum. Kjerulf 1865, p. 1, fig. 2, 3.
Dictyograptus flabelliformis Eichwald, forma *typica.* Brøgger 1882, p. 36.

Preservation. The fossils occur in a black phyllitic shale. The graptolites are strongly flattened, but have also been subject to horisontal stress as shown in fig. 1 on the plate. In spite of the considerable compression, however, the fossils are comparatively well-preserved.

Description. The large and coarse-meshed colonies attained a length of stipes exceeding 150 mm and a width of rhabdosome even greater still. Certain large specimens show that the rhabdosome is characteristic by its less diverging initial portion and a constantly diverging distal portion. The outer borders, which are but slightly convex, form an angle of about 90°, giving the colonies a subtriangular outline in preserved state. The stipes are uniform and parallel. The density of stipes are dependant on the compression, and the measured variation of 5—9 in 10 mm should therefore be limited to 6—8. The dissepements are rather constant in number, about 5 in 10 mm, but they vary considerably in thickness as shown in fig. 1 and 2 of the plate. Fig. 2 has the thick cross-bars characteristic of the variety, while the other in fig. 1 resembles the forma typica, although certain thicker dissepements are always traceable. The latter form evidently induced Brøgger to include the form of Holberget in the forma *typica*.

Relationship. The described form, which represents the bulk of the graptolites at Holberget, belongs to the variety *Dictyonema flabelliforme norvegica.* Transition forms pointing to the forma *typica* occur just as in Great Britain (Bulman 1927—1928, p. 26).

Dictyonema flabelliforme (Eichwald) forma *typica* Brøgger.

Besides the above described variety certain specimens from the collections of Brøgger and Rekstad show also the presence of the forma *typica*.

Clonograptus sp. (?)

Certain pieces of shale contain numerous fragments of single branches or stipes which probably belong to branched graptolites of the *Clonograptus* or perhaps *Anisograptus* type (Ruedemann 1937).

Obolus sp.

Pl. fig. 3.

The material collected by Rekstad contains a number of specimens which apparently represent the compressed remains of inarticulate brachiopods. Certain shells have a slightly blueish colour indicating phosphatic shells. Fig. 3 on the plate shows one of the specimens which has an ovate outline with a length of 4 mm and a width of 8 mm. The concentric striæ are distinct, but may in certain cases have been acsentuated by the stress of the shale. The preservation of the specimens does not permit a distinct determination, but the brachiopods resemble in shape and size the species *Obolus (Brøggeria) salteri*

Hall which occurs in the Dictyonema Shale and Ceratopyge zones in the Oslo Region.

The fossils of Holberget show that the shale belongs to the Dictyonema Shale (2e) and mainly the upper part (2e γ) of this basal zone of the Ordovician.

Dvergsminut, Hardangervidda.

In 1902 Rekstad (1903, p. 21) discovered a new *Dictyonema*-locality at Dvergsminut 20 km south of Holberget on Hardangervidda. In his description of the locality he mentions the presence of the fossil *Dictyonema flabelliforme.*

Dictyonema flabelliforme (Eichwald) forma *typica* Brøgger.

Pl. fig. 5.

Preservation. The black shale is similar to that of Holberget, but the fossils are less compressed. A secondary schistosity is indicated.

Description. Rhabdosomes of this form is common in the material. One specimen (No. 287 PMO) shows an outline of the rhabdosome corresponding to the maximum dispersion given by Bulman (1927—1928, text-fig. 12) of the forma *typica.* The basal portion of the rhabdosome shown in fig. 5 (to the left) on the plate, has an even greater dispersion which might indicate the variety *D. f. anglica* Bulman, but the angles might also to a great extent be due to an oblique preservation. The other specimen in fig. 5 shows the typical stipes and dissepements of the forma *typica.* The number of stipes is 8—9 in 10 mm, and the number of dissepements 4 in 10 mm.

Relationship. The bulk, if not all of the specimens belong to *D. f.* forma *typica.* Certain broad rhabdosomes in the material might possibly belong to *D. f. anglica.*

Bryograptus kjerulfi Lapworth (?)

Pl. fig. 4.

The figured specimen probably belong to this species which occurs in the upper part of the Dictyonema Shale of the Oslo Region. The narrow rhabdosome measuring 29 mm in length, has close set stipes branching at small angles and lacking the dissepements characteristic of the genus *Dictyonema*. A distinct determination is not possible, but the regular stipes and the shape of the rhabdosome suggest this species more than others described from similar beds (Westergård 1909 and Monsen 1925).

Clonograptus (?) sp.

As in Holberget singular graptolite branches occur which might belong to the genus *Clonograptus* or similar forms.

The fossils of Dvergsminut show that these beds belong to the Dictyonema Shale (2 e). Besides the subzone 2 e β, slightly younger fossiliferous beds seem to be present.

Snertingdalen.

In his paper on the Cambrian beds of the Mjøsen District Strand (1929) mentions the find of *Dictyonema flabelliforme* in a road cut just north of Sten farm in Snertingdal northwest of Gjøvik. The locality thus lies outside the Oslo Region. Dr. T. Strand has kindly permitted me to describe the occurring species.

Dictyonema flabelliforme aff. *norvegica* (Kjerulf).

Pl. fig. 9, 10.

Preservation. In spite of their occurrence in a district with considerable overthrusts, the fossils in the black shales are well preserved. As a rule the graptolites are compressed into glistening films, but in a few cases they are more plastically preserved showing the cells as shown in fig. 9 of the plate.

Description. The outline of the rhabdosome is not well demonstrated in the specimens preserved, but the divergence of stipes in several fragmentary specimens shows that the outline probably was subtriangular in preserved state just as in *D. f. norvegica*. The thick stipes are usually somewhat irregular as demonstrated in fig. 9 on the plate. In larger specimens (fig. 10) the stipes are more straight such as in ordinary types of *Dictyonema flabelliforme*. The number of stipes is 8—12 with 8—9 in 10 mm as the most common.

The dissepements are subject to variation. As shown in the photographs they appear both as thin threads and solid cross-bars. Certain oblique bars may have served as anastomosing branches between the stipes. A small fragment has very broad dissepements such as in extreme forms of *D. f. norvegica.* The number of dissepements is 4—5 in 10 mm. The number of thecæ is 19—20.

Relationship. The described form shows distinct affinities to *Dictyonema flabelliforme norvegica* which has a similar shape of the rhabdosome and a corresponding development of the dissepements. The thin dissepements, so common in most of the specimens, indicate an intermediate form similar to one described by Bulman (1927—1928, text-fig. 14) from Great Britain. On the other hand the less regular stipes, which is partly significant also in the British form, point to a possible connection with the variety *D. f. desmograptoidea* described by Hahn (1912, p. 139) from America.

The described graptolite species from Snertingdal evidently belongs to the Dictyonema Shale (2 e) and probably the middle part of this zone (2 e β—γ).

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Explanation to the plate.

Reproduced photographs not retouched. Specimens figured in natural size.

Fig. 1—2. *Dictyonema flabelliforme norvegica* (Kjerulf). Holberget, Hardangervidda. T. Dahl coll. No. 261 Pal. Mus. Oslo Coll.

Fig. 3. *Obolus* sp. Several specimens from Holberget, Hardangervidda. J. Rekstad coll. No. 274 Pal. Mus. Oslo Coll.

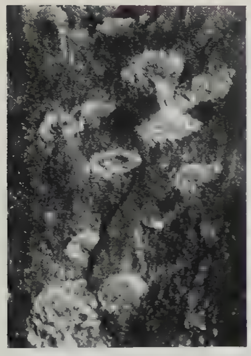
Fig. 4. *Bryograptus kjerulfi* Lapworth (?). Dvergsminut, Hardangervidda. J. Rekstad No. 281 a Pal. Mus. Oslo Coll.

Fig. 5. *Dictyonema flabelliforme* forma *typica* Brøgger. Dvergsminut, Hardangervidda. J. Rekstad coll. No. 284 Pal. Mus. Oslo Coll.

Fig. 6—8. *Dictyonema flabelliforme sociale* (Salter). Nordaunevoll, Holtålen. Th. Vogt coll. The specimens belong to Norges Tekniske Høgskole.

Fig. 9—10. *Dictyonema flabelliforme* aff. *norvegica* (Kjerulf). Snertingdal. T. Strand coll. No. 35874, 35914 Pal. Mus. Oslo Coll.

Leif Størmer: Dictyonema Shales Outside the Oslo Region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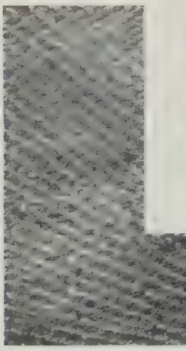
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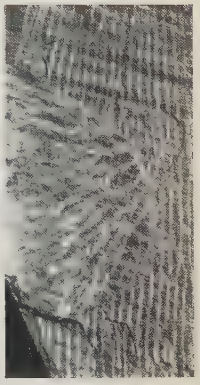
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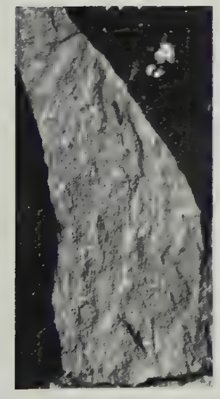
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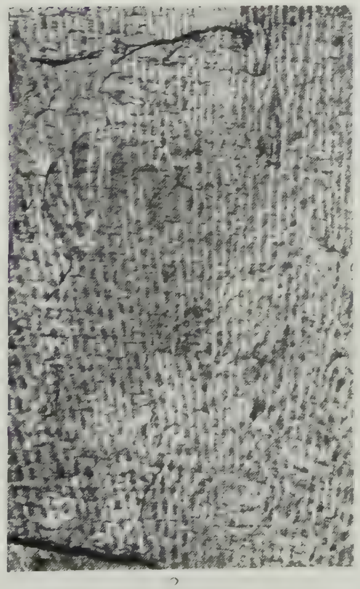
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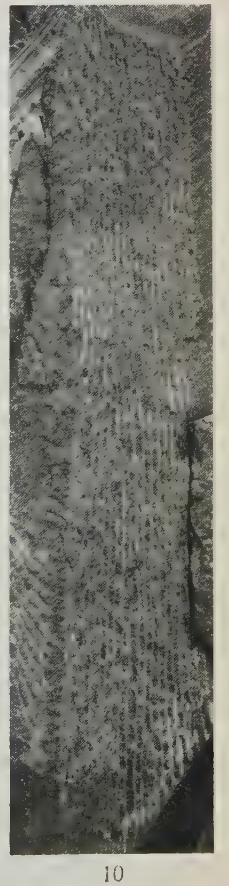
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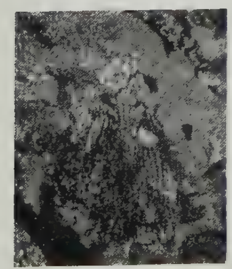
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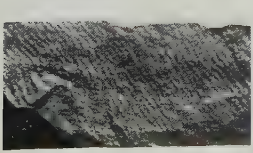
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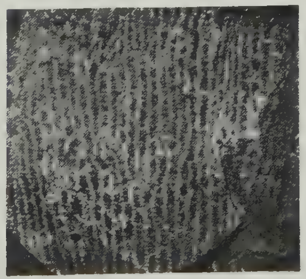
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Ms. rec. March 8, 1940

GEOLOGICAL NOTES ON THE DICTYONEMA LOCALITY AND THE UPPER GULDAL DISTRICT IN THE TRONDHEIM AREA

BY

THOROLF VOGT

WITH 1 PLATE AND 5 FIGURES IN THE TEXT

Abstract. A description is given of the *Dictyonema* locality from the metamorphic series of the upper Guldal district. It is further given a synopsis of the geology of this area, principally based on old unpublished observations by J. H. L. Vogt. The stratigraphy of the metamorphic series, and the position of the *Dictyonema* horizon, is discussed, the "Drøia series" being described, representing the lower part of the Gula series of Kjerulf. As to the general tectonics, a central synclinal system of the Trondheim area is suggested. Mention is made of andalusite bearing mica schists, representing a mineral facies different from the cyanite bearing facies further to the northwest, the latter being formed under higher pressure. The influence of carbonaceous matter on grain size and porphyroblast formation in metamorphic argillaceous sediments is considered.

The locality of *Dictyonema flabelliforme* (Eichw.) at Nordaunevoll represents an isolated fossil find on the eastern side of the Trondheim area, at about 62° 54′ N and 0° 44′ E Oslo. It is of considerable interest as to the stratigraphy of the region, being the only cambro-silurian fossil find within a range of about 60—70 km. It represents further the oldest fossil horizon known from the Trondheim area.

The graptolites were discovered in July 1888 by J. H. L. Vogt (1889) and mentioned by him on a discourse the 16th of November the same year. Once more, in August 1889, he paid a short visit at the place. Later C. W. Carstens (1920) visited the locality several times during the years 1913 to 1919, and communicates remarks on the geology and descriptions of some rocks (vide p. 43, 60 and 101), a general profile (Pl. 18, Fig. 3), and also a photograph (Pl. 1 Fig. 1).

Many points, however, being obscure, the fossils also neither being described, I paid a visit at Nordaunevoll in the first part of September 1937. The fossil collection was handed to Dr. Leif Størmer, who kindly has described them (1940, see the preceding paper). At present I shall give notes on my observations from the locality itself, and remarks on the geology of the district, the latter principally based on the unpublished geological map and diary of J. H. L. Vogt.

I have the pleasure to forward my thanks to Director Dr. Carl Bugge, who placed a copy of the geological manuscript map Holtålen at my disposal, and to professor dr. V. M. Goldschmidt, who furnished me with informations, and rock specimens from the Geological Museum of Oslo.

Description of the Nordaunevoll Locality.

Nordaunevoll, a summer outfarm above the wood limit, at my visit uninhabited, is situated in the eastern part of the topographical sheet Holtålen. The rock ground of the valley being heavily covered with morainic drift, outcrops are rather scanty. The graptolite-bearing black shale is exposed in a brook gully about 500 m to SE of Nordaunevoll, near the outfall of the brook in the river Hulta (Holta). The name of this brook, not given on the topographical map, is Blåhénbekken (= Blåheinbekken), from blå (= blue, and also black in old norse), and hein (= hone, whetstone), indicating an old-time local use, now, I think, forgotten, of the black shale as whetstone. The rock splits into fairly suitable pieces for this use, too, viz. after the bedding plane and an inclined tectonic cleavage. The river name Heina, in the neighborhood, may possibly have a similar origin.

As will be seen from the sketch map fig. 2 and the profile fig. 3, the black shale is forming an almost vertical bed between two amphibolites, which the present author, like Carstens, interpret as intrusive sheets. The greatest visible thickness of the bed was about 12 m whereas the length of the exposure was estimated to about 100 m. The strike is 0 25° N, and the dip about 80° to SSE. The shale, as well as the amphibolite to the south, is transversed by a tectonic cleavage, which dips about 80° to NNW. The shale splits to thin laminae especially after the bedding but also after the jointing, and makes an almost unmetamorphic impression at the first glance.

The Dictyonema was found profusely in an 0.3 m thick layer, near the southern boundary of the black shale (in the profile from 1.6 to 1.9 m from a brown schist to the south). In this zone almost every piece picked up was fossiliferous, whereas no specimen was

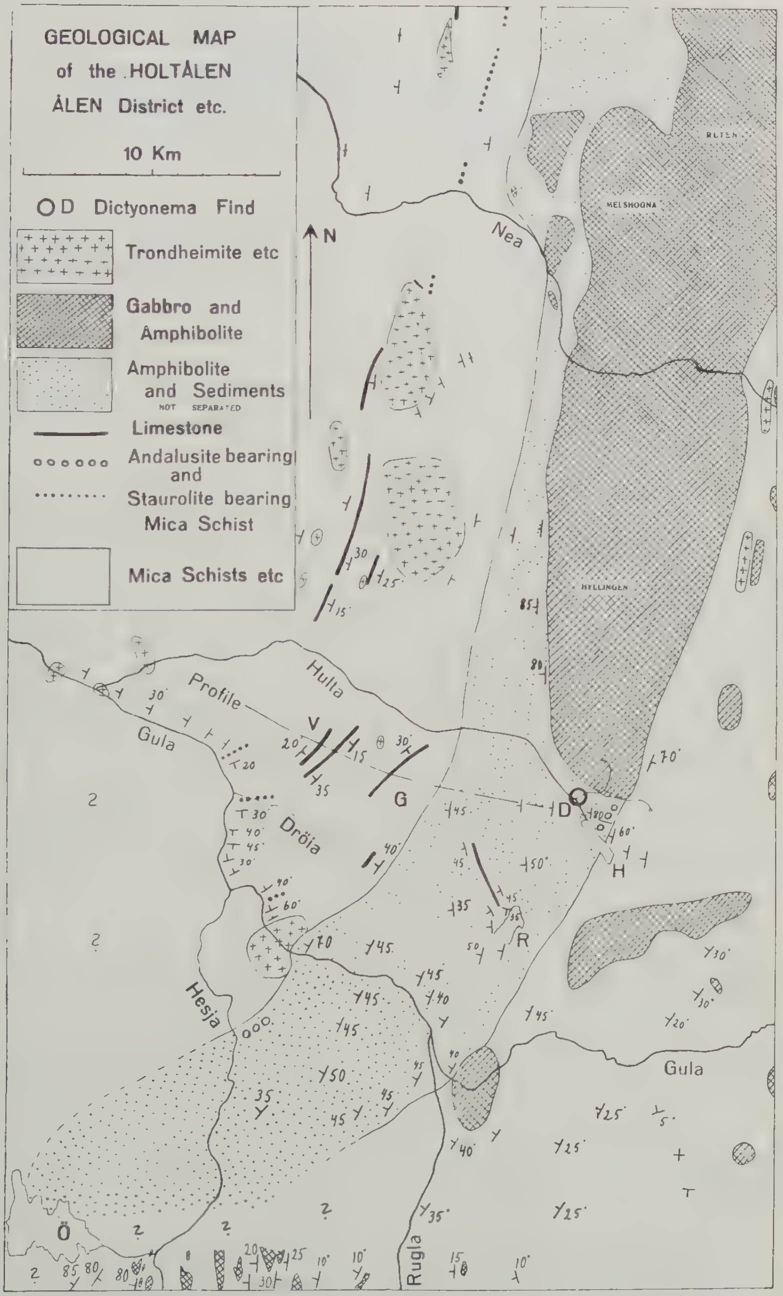
GEOLOGICAL MAP
of the HOLTÅLEN
ÅLEN District etc.
10 Km
O D Dictyonema Find
Trondheimite etc
Gabbro and Amphibolite
Amphibolite and Sediments
NOT SEPARATED
Limestone
Andalusite bearing and
Staurolite bearing Mica Schist
Mica Schists etc
N
Nea
RUTEN
MELSHOGNA
HYLLINGEN
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Fig. 1.

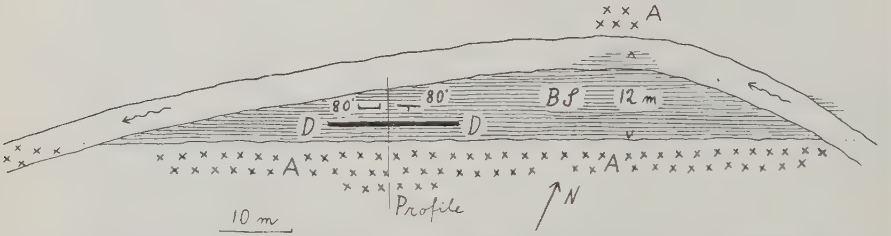

Fig. 2. Sketch of the Dictyonema locality at Blåhénbekken, near Nordaunevoll. BS = Black shale. D-D = The Dictyonema horizon. A = Intrusive amphibolites.

collected outside. It may be mentioned that J. H. L. Vogt, in his diary, notes the thickness of the fossiliferous zone just to 0.3 m.

The following small profile was studied closer and measured (vide fig. 3):

1. Porphyritic amphibolite. The medium to rather finegrained groundmass consists of much plagioclase and ordinary green hornblende, a little bright brown biotite, and small grains of titanite, whereas no chlorite was observed. Almost all clinozoisite was confined to the phenocrysts. The groundmass plagioclase had the following composition:

Section $\perp \alpha$ $\gamma' \pi = +20^\circ \rightarrow +14^\circ$ 31% An → 27% An
Section $\perp \alpha$ $\alpha' M = +9^\circ$ 27% An.

The phenocrysts of plagioclase were partly quite undecomposed, and partly filled with clinozoisite and some sericite. An undecomposed phenocryst had the following composition:

Section $\perp \alpha$ $\alpha' M = +25^\circ$ about 52% An.

2. Very finegrained amphibolite. This rock is composed of a very finegrained mixture of plagioclase and bright green hornblende with clinozoisite, iron ore, and titanite. No chlorite was observed. These two rocks, and especially the last, have crystallized from their magmas during rather rapid cooling. They are now metamorphosed to the transition between the amphibolite facies and the epidote-amphibolite facies.

3. Brown biotite schist with muscovite porphyroblasts. (Pl. Fig. 3.) This rock is a fine grained, rather massiv, dark to blackish brown schist,

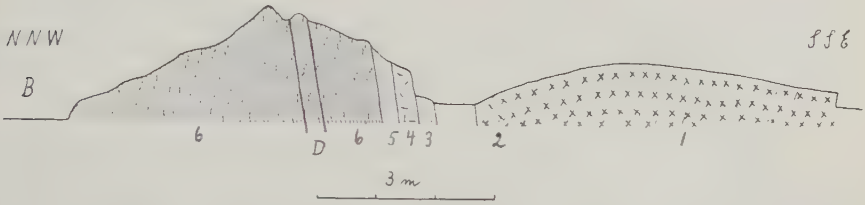

Fig. 3. Profile at the Dictyonema locality at Blåhénbekken, cp. fig. 1. 1 = Porphyritic amphibolite. 2 = Very finegrained amphibolite. 3 = Brown biotite schist. 4 = Black muscovite porphyroblast fels. 5 = White sericite shale. 6 = Black shale, D = The Dictyonema horizon. B = Blåhénbekken.

consisting of dark brown biotite, quartz, clinozoisite, and finely dispersed carbonaceous matter. In this groundmass are scattered a few porphyroblasts of muscovite.

4. Black muscovite porphyroblast fels. (Pl. Fig. 5 and 6.) This rock, black and wholly massiv, for a great part consisting of close lying grains of a mineral (muscovite) with black cleavage planes, has a peculiar resemblance to a somewhat recrystallized black stinkstone. The very finegrained groundmass is more or less filled with finely dispersed carbonaceous matter, consisting otherwise of quartz, sericite, and iron ore. The muscovite porphyroblasts, up to ½—1 mm across, and lying in all directions, are generally filled with carbonaceous matter except for the clear margin. Sometimes the carbonaceous matter is arranged in a chiastolite like manner. The optical character is negative, 2 V = about 40°, and $\gamma_{Na} = 1.601$.

5. White sericite shale. This shining white shale, consisting principally of sericite and quartz, is devoid of carbonaceous matter. Probably it is derived from a black shale through some gas reaction, which has removed the carbon.

6. Black shale. (Pl. Fig. 1.) A very fineclastic shale, blackening, and with black streak. The thin sections are almost black from carbonaceous matter, and only with traces of new formed minerals. Sericite is present in very fine flakes, the thin sections being somewhat brighter, between crossed nicolls, in diagonal than in parallel position. Narrow veins, corresponding to the tectonic cleavage, are

filled with muscovite without carbonaceous substance. The graptolite bearing and the surrounding non-fossiliferous shale are identical from the look and under the microscope.

7. Black actinolite porphyroblast shale. (Pl. Fig. 2.) Outside the profile, and further to the north in the series, appear a black shale similar to that mentioned above, but with rather great porphyroblasts of actinolite. Like the preceding shale, it splits easily after the bedding plane, and also after the tectonic cleavage. The shale is dark grey to black, with dark grey to black streak, and only just blackening. The groundmass, not being quite as finegrained as in the preceding rock, and also with lesser carbonaceous matter, is seen to contain distinct although very small sericite flakes, and quartz. The actinolite porphyroblasts, of size up to about 1 × 20 mm, are filled with carbonaceous matter except for a very narrow clear margin, the color of the mineral, therefore, being from look black. Where crystal faces are seen the columns are bounded by 100 and 110, and flattened after 100. Under the microscope the mineral is colorless, optical negative with great 2 V and with dispersion of the optic axes $\rho < \nu$. In section $\perp \beta$, $c\gamma = 14°$. On cleavage laminae the refraction were:

$$\alpha'_{Na} = 1.624$$
$$\gamma'_{Na} = 1.636.$$

8. Amphibolite. On the north side of the brook, outside the profile, a small outcrop of amphibolite was seen. This rather coarse grained rock is consisting of bright green hornblende, which forms the bulk, plagioclase, a little bright brown biotite, and iron ore. No clinozoisite or chlorite was observed.

Some hundred meters to SW from the Blåhénbekken locality, a black shale is exposed in the river bed of Hulta. To all appearance it is the same bed as that described above, forming also the direct continuation. As will be seen from the fig. 4, the black shale is bounded, also here, of amphibolites. The black shale is of the same character as in the preceding locality. No fossils were found, only a short time, however, could be used in search.

Interbedded in the black shale appears a bed, about 1 m thick, of a wholly massiv, bright brown biotite schist, with a peculiar

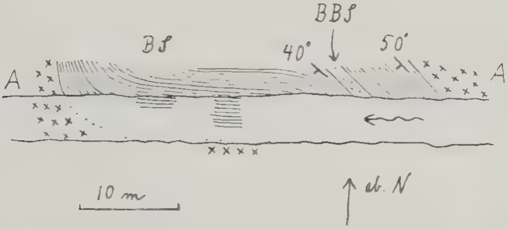

Fig. 4. Sketch of the outcrop of the black shale at Hulta immediately to the west of the outlet of Blåhénbekken. BS Black shale. BBS = Brown biotite schist. A = Intrusive amphibolite.

yellowish red coat of weathering. The rock (cp. Pl. Fig. 4) contains a very bright brownish coloured biotite, the flakes being placed without markedly parallel arrangement, quartz, plagioclase, clinozoisite, a little almost colourless hornblende, titanite and pyrrhotite. In this matrix occur irregular porphyroblasts of calcite. Possibly this bed is identical with the biotite schist, bed 3, in the Blåhénbekken profile.

Black shales seems, moreover, to be rather abundant in the neighborhood. They are mentioned, thus, in the diaries of J. H. L. Vogt, from the region between the Dictyonema locality and Haltsjøen (H on the geological map fig. 1), from the northeastern side of Haltsjøen, and also from the northeastern side of the mountain Haltsjøhøgda (NW of Haltsjøen). Discovery of fossils in these shales might be anticipated.

Notes on the Geology of the Upper Guldal District.

The geological map fig. 1 is compiled from the following sources: The greater part of the map represents the manuscript map of J. H. L. Vogt of the eastern part of the sheet Holtålen. Statements on this sheet indicating strike and fall are principally entered from the diaries of J. H. L. Vogt from 1888 and 89, as also the occurrence of the staurolite bearing mica schists and of some of the limestones. The occurrence of the andalusite bearing rock from the Hesjedal is marked down from personal communication of V. M. Goldschmidt to the present author. The boundaries to the NE of the lake Øiungen (Ø on the map) are due to K. M. Hauan (cf. G. Holmsen

1915), who travelled in the district in the 1870 years. In the southeastern corner the summary map of G. Aasgaard (1927) is used. The detailed geological mapping, now in work on the base of air photographs in scale 1 : 10 000 on account of Røros Kobberverk A/S, is principally covering the area to the south of the present map. Only on the southern margin some details from these maps are entered. The geological work in the Røros area is performed by the present author, assisted by several young geologists. To the east the map is completed with a narrow stripe of the sheets Stuesjø and Essandsjø, from the geological maps in scale 1 : 300 000 published in the paper of Hans Reusch (1896). To the north a part of the published geological map Selbu (Homan 1891) is included. The Selbu millstone horizon on this sheet, representing a staurolite and almandite, often also cyanite bearing mica schist, is marked down from personal communication to the present author of the late postmaster Paul Birch, the best connoisseur of the old millstone industry of Selbu, now long in disuse.

The gabbro intrusions will be mentioned at first. The large gabbro area to the north of Haltsjøen (H), which may be called the Fongen gabbro area after the highest mountain Fongen (1459 m above s. l.), is, as it seems, principally consisting of olivine gabbro, at least in the central parts. Törnebohm (1896), thus records coarse grained olivine gabbro from the mountains Melshogna and Hyllingen, and Carstens (1920 p. 102) describes olivine gabbro from Fongen. This rock, from a thin section in our collection, also appears to the east (NE) of Nordaunevoll, consisting here of basic plagioclase, olivine, diallage, hypersthene, and magmatic hornblende, forming a rather coarsegrained, quite unmetamorphic olivine gabbro. Törnebohm (1896) further records partly olivine bearing rocks from the area to the NE of Øiungen (Ø). The other gabbro rocks on the map apparently all are metamorphosed, principally to amphibolites and epidote amphibolites, partly, however, also to greenstones.

The present author studied the metamorphic gabbro rocks along the path on the north side of Hulta, between the Dictyonema locality (D) and the western boundary of the intrusion zone near Haltdalsvoll. In this profile extremely little sediments were seen, the rock ground, however, being much covered with morainic drift. The rocks were consisting of amphibolites without clinozoisite, amphibolites with some clinozoisite, epidote amphibolites, and occasionally, epidote amphibolites with chlorite. They were coarse grained to medium and rather fine grained, the more fine grained rocks often in porphyritic development. Sometimes a more femic amphibolite are veined by a salic amphibolite, the former rock with scattered and the latter with close lying phenocrysts of plagioclase. In the field the rocks have the appearance of being injections, an impression confirmed by the microscopic examination. No trace of effusive structures have been observed. In his diaries, J. H. L. Vogt also often mentions amphibolites cutting the sediment beds.

On the southern margin of the map, and further to the south, as far as we have worked, the amphibolites occur as lenses and sheets of intrusive origin. The present author also studied the amphibolites at Gudå in the Meråk valley, in the same amphibolite zone further to the north, and outside the map, only finding intrusive amphibolites (epidote amphibolites).

As to the regional distribution of the other intrusive rocks on the map, it may be pointed out that granitic rocks, at least principally Trondheimites, are prevailing to the west of the Fongen intrusion zone, whereas, gabbroide rocks, principally epidote amphibolites etc. are prevailing to the east. In the Røros area the last feature is very marked. Amphibolites and partly greenstones are occurring here abundant in various folded injection zones to the east of the Fongen zone. Granitic material are, on the other side, not found at all before in the eastern part of the Fongen zone itself, or in zones immediate to the east of the latter.

Passing now to the sediments, the degree of metamorphism is generally increasing towards northwest, corresponding to the map of metamorphism of the Trondheim area by V. M. Goldschmidt (1915). Attention is called to the fact, that certain old local names, though partly used in a stratigraphical sense, originally are petrological names, used as field names on various types of schists, different in regard to metamorphism and composition.

The prevailing schists to the east of the Fongen zone are, in the diaries of J. H. L. Vogt, called *Røros schists* or schists like the latter. The Røros schists from the present area, e. g. from Lilleskarven and Sørensfjell in the SE corner of the map, are described, in the diaries, as shining and uneven, evidently muscovite rich schists, often with garnet or needles of hornblende ("Garben" schists), or both minerals, and mostly with small lenses of quartz. Th. Kjerulf

(1871) used the epithet Røros schist proper to muscovite rich "Garben" schists in the Røros area. To the east of the Fongen zone, also sandstones occur, e. g. on hill 1052 m to the south of Meinatjern, as described by C. W. Carstens (1920). *The Stuedal schist*, a name given by Hans Reusch (1896), represents a muscovite bearing biotite porphyroblast schist, occurring outside and to the east of the present map.

The prevailing schists near to the west of the Fongen zone, was named *Drøia schists* in the diaries of J. H. L. Vogt, from the river Drøia, marked on the map. The typical Drøia schist is described as a dark brown, uneven and often rusty biotite schist, garnet bearing, and often with quartz lenses containing cyanite.

Two key zones are occurring in these Drøia schists. The one is the *Vollfjell limestone*, including, in the opinion of the present author, all limestones marked down in the western area of the map, perhaps except the small limestone at the Rauhammer pyrite deposit, i. e. the eastern limestone near to the north of Hulta. This latter limestone may represent an inverted part of the Vollfjell bed, or it may belong to a somewhat lower zone. The thickness of the Vollfjell limestone is recorded to be about 25—30 m near Tveråseter, i. e. in the western limestone near to the north of Hulta, thinning down to only 1 m towards the north. Further to the north, at Ustensjøen, Th. Kjerulf (1875) denotes, from the observations of K. M. Hauan, the thickness to again about 100 feet. In the Vollfjell itself the thickness is about 25 m, the zone consisting here of 1 to 6 m thick beds of rather pure limestone, with thin layers of schist between the beds. In the profile fig. 5, the folds on the Vollfjell and the Grønfjell are drawn from several field sketches in the diaries, whereas the connection to the west is indicated by the anticline in the Guldal.

The other traceable zone in the Drøia schist is the *Selbu millstone* horizon, representing a staurolite porphyroblast schist with garnet, biotite etc., sometimes also containing cyanite, compare the petrological description of C. W. Carstens (1928). This zone has been worked for millstone from the locality to the south of Nea to the beds at the northern margin of the map, and about 13 km further to the north. To the south of this millstone horizon proper, garnet bearing staurolite schist are mentioned by J. H. L. Vogt, in his diaries, partly also with figures of staurolite twins, from the following localities

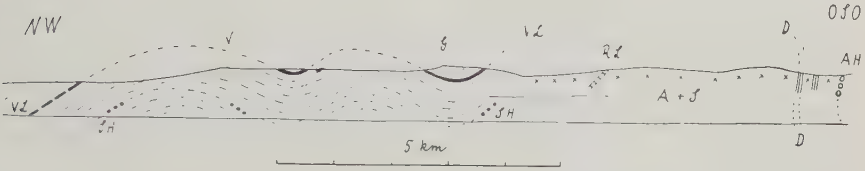

Fig. 5. Profile across Vollfjell (V) and Grønfjell (G) to Haltsjøen, cp. the map p. 173. VL-VL = The Vollfjell limestone. SH-SH = The Staurolite bearing horizon in the mica schist, from the profile along Gula. RL = The Rensjø limestone. A + S = Amphibolite and sediments, not separated. D-D = The Dictyonema shale. AH = The Andalusite bearing horizon in the mica schist. The beds marked with dotted lines below the Staurolite bearing horizon, between the latter and the Vollfjell limestone, and above the latter, represent the Drøia schists.

in the Guldal: ½ to 1 km to the NW of the trondheimite boundary at Eidet, at Ramlo, and at the Drøia bridge. At Ramlo, cyanite, furthermore, was present in the staurolite mica schist itself, whereas the former mineral was found only in quartz lenses at the Drøia bridge locality. These three localities are placed in the profile fig. 5. In the opinion of the present author, the identity of the staurolite bearing millstone horizon in Selbu and the staurolite bearing schist in Guldal can hardly be doubted. This staurolite bearing horizon clearly also represents a lower zone than the Vollfjell limestone.

As it appears from the profile fig. 5, the Drøia schists with the mentioned two key horizons, are resting on the injection zone of the amphibolites and the Fongen gabbro. The *Rensjø limestone*, to the northwest of Rensjøen (R on the map), in this injection zone, is very different from the Vollfjell limestone, being impure and mixed with quartz and mica, furthermore alternating intimately in thin layers with schists. The coat of weathering is characteristic yellow, forming a conspicuous feature of distinction from the Vollfjell limestone. It also differs from the limestone at the Rauhammer pyrite deposit, which is similar to the Vollfjell limestone. The thickness of the Rensjø limestone zone is about 75 m near the Limsteintjern.[1] In railway cuts in the Guldal, not far to the southeast from the Store Rena, numerous only about 1 cm thick layers of limestone with yellow coat of weathering is occurring in the mica schist. In his diary, J. H. L. Vogt assumes this limestone rich zone to be a continuation of the Rensjø limestone. Traces of similar limestone are also mentioned from the Storhøgd and the Storvoll mines, on the west side of the Guldal. As to the stratigraphical position of the Rensjø limestone, it seems at least to belong to a lower horizon than the Vollfjell limestone.

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[1] The name on this small tarn, about 850 m above s. l. is derived from the old norse name on limestone (limstein), still living in some norwegian dialects, especially, however, in topographical names.

At the outlet of the lake Rensjøen, and just to the west of this outlet, J. H. L. Vogt observed some small conglomerate beds, 1 to 2 m thick, with deformed pebbles, the latter mostly consisting of quartz (quartzite), one pebble of granite, however, being also observed. The stratigraphical position of this conglomerate may be near to that of the Rensjø limestone, but wether above or below must be left undecided.

Turning now to the *Dictyonema* shale, the observations do not at present admit of a quite positiv solution of the stratigraphical position of the latter. The following features may, however, be emphasised.

Reference is first made to the relation between the jointing and the bedding appearing in the profile fig. 3 from Blåhénbekken. This jointing implies, as well known, under ordinary uncomplicated folding conditions, an anticline to the northwest and a syncline to the southeast of the profile. If so, the beds at Blåhénbekken are occurring in normal position, whereas the beds at Hulta are inverted. Outcrops of the black shale being not known, however, to the northwest of the Blåhénbekken—Hulta bed, the size of the presumed anticline is also unknown. The anticline may be inconsiderable or large-sized.

Another feature of interest is the occurrence of a key horizon, viz. an andalusite porphyroblast schist, to the southeast of the Dictyonema shale, as marked on the map p. 173. After having found erratics of an andalusite bearing mica schist in the valley between Nordaune and Høgvoll, and near Høgvoll, J. H. L. Vogt detected the outcrop of this rock near the northern termination of the Haltsjø, on the east side of the lake. The rock is described, in the diary, as an andalusite and garnet bearing mica schist with great crystals of andalusite, occurring with various mica schists.

Three specimens of this interesting rock are at hand from the Haltsjø environments, all from erratics found to the northwest of the outcrop, in the general direction of the ice flow. One from the Haltdal (the valley between Nordaune and Høgvoll), collected by

J. H. L. Vogt and kept in the Geological Museum of Oslo, another collected by C. W. Carstens between Nordaunevoll and the Blåhénbekken locality, and a third from Blåhénbekken itself, collected by the present author. The latter specimen represents a striking and beautiful rock, with large unaltered porphyroblasts of andalusite (up to 8 × 8 × 18 mm in size), and smaller porphyroblasts of staurolite and garnet in a biotite and muscovite rich groundmass. The other two specimens contain smaller porphyroblasts of andalusite, more or less paramorphosed to cyanite.

Similar rocks are known also further to the southwest. At Vårhus in the Hesjedal, V. M. Goldschmidt, after personal communication to the present author, found an andalusite porphyroblast schist, the large andalusite crystals being partly paramorphosed to cyanite. In his paper on the Stavanger area, Goldschmidt (1921 p. 45) also touches on this rock. This occurrence is marked on the map to the right of the name Hesja.

Further specimens of andalusite mica schist were collected from the Harsjøfjell in old time (the labels being written with the hand of Th. Kjerulf), and kept in the Geological Museum of Oslo. The andalusite porphyroblasts of this rock are also partly paramorphosed to cyanite. This locality is situated roughly in the continuation of the Vårhus beds, and about 15 km to SSW from the latter.

The occurrences of andalusite porphyroblast schist at Haltsjø, Vårhus and Harsjøfjell, being also the only known finds of andalusite from the Caledonian range of Norway, presumably belong to about the same stratigraphical horizon. The occurrences near the southeastern and the northwestern boundary of the amphibolite zone, at Haltsjø and at Vårhus, points to a repetition of the bed through folding.

These andalusite porphyroblast schists are chemically near related to the staurolite and cyanite bearing schists and the millstone horizon mentioned above, all representing sediments extremely poor in CaO and rich in Al_2O_8. In fact, these rocks represent two different mineral facies, separated through the equation: Andalusite $\rightleftarrows$ Cyanite.

The extensive paramorphism[1] of andalusite to cyanite indicate that the andalusite bearing mineral facies first formed, generally became unstable at a later point of time, in the development of the metamorphism. The occurrence of the andalusite bearing rocks near magma injections, also pointed out by V. M. Goldschmidt (1920 p. 45), may indicate a relative high temperature for the formation of this equilibrium, whereas the cyanite certainly belongs to an equilibrium formed under comparatively high pressure. The transition from the one mineral facies to the other supposedly is due to changes in the PT-relations as indicated.

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[1] A simultaneous formation of the andalusite, and the cyanite bundles in this mineral may not be excluded, this alternative making, however, in principle no differance as to the existence of the two different mineral facies.

As to the stratigraphical position of the andalusite porphyroblast horizon, it may be contemporaneous with the staurolite bearing millstone bed, or belong to a lower horizon, whereas a position higher up in the series seems less probable. The *Dictyonema* shale supposedly belongs to a horizon below the Selbu millstone bed (and, may be, also the andalusite porphyroblast schist).

The present preliminary review of the geology of the upper Guldal district is then conveying to the following stratigraphical series:

6. Mica schists, upper bed.
5. The Vollfjell limestone.
4. Mica schist.
3. The staurolite bearing Selbu millstone horizon.
2. Various sediments.
1. The black Dictyonema shale, lower bed.

The appellation Drøia series is used on the series 3 to 6. As a matter of fact, J. H. L. Vogt used the designation Drøia schists, though laying stress on the petrological properties of the sediments, on all schists in the Drøia series. Now, however, it may be recommended to use the international petrological names on the different rocks in question, and keep the local names for stratigraphical use, without referance to the metamorphic habit the sediments may possess.

Unplaced in this series is the andalusite bearing mica schist, supposedly contemporaneous with or older than the Selbu millstone horizon; further the Rensjø limestone and the conglomerates near this bed, both, however, supposed to be older than at least the Vollfjell limestone.

The series below the *Dictyonema* bed will not be discussed at present, it is, however, assumed that at least a part of what has been termed the Røros schists is lying below this horizon.

The Synclinal Character of the Central Part of the Trondheim Area.

The left part of the profile fig. 5 evidently forms the eastern flank of a large syncline, a feature more pronounced when taking into account the further continuation of the profile towards northwest. This profile confirms, in fact, the old conception of Th. Kjerulf of this part of the Trondheim area. One may compare our fig. 5 with especially the general profile of Kjerulf (1875 p. 38 and 40) through the Guldal. The two synclines of Kjerulf, between Eidet and Drøia, and between Drøia and Holtaelv, obviously are corresponding to our two synclines at Grønfjell and Vollfjell. Only further to the northwest, outside our profile fig. 5, the beds generally seem to dip steeper towards NW than marked down by Kjerulf. The Drøia series, then, is corresponding to the lower part of the Gula series of Th. Kjerulf. In a similar way, the present observations confirm the view of C. Bugge (1910) concerning the eastern part of the Trondheim area.

A discussion of the general tectonics of the Trondheim area will not be entered upon a present. It may, however, be mentioned, that the assumption by the present author of a synclinal character of the central Trondheim area, discrepant with the view of C. W. Carstens (1920), do not interfere with his, as it seems, well established interpretation of the tectonics further to the NW, viz. in the Støren—Hovin area. One should only expect an anticline, to the east of the Støren effusive greenstone, of smaller size than assumed by Carstens. The existence of such a smaller anticline was to some degree confirmed, on an excursion with A. C. Waters some years ago, through the find of a thin bed of effusive greenstone material between Bones and Refset in the Guldal, near to the west of the entrance of Budal. This occurrence, though not being conclusive, is at least in accordance with the suggestion mentioned above.

The effusive greenstones, forming such enormous thick masses on the northwestern side of the Trondheim area, between Rennebu—Meldalen and Snåsa, seem generally, after the experience of the present author, to dwindle rapidly towards the southeast. This means that one practically is losing the effusive greenstone as a key horizon in the southeastern areas. In the opinion of the author it is necessary to pay attention to this fact in attempting to disentangle the structure of the central parts of the Trondheim area.

The Fongen Injection Zone.

The Fongen gabbro area, the southern part of which is marked on the map to the north of Haltsjøen, is forming the central part of an extended injection zone. To the north of this large gabbro body, more or less separated amphibolite injections can be followed, on the old geological maps Selbu (Homan 1891), Stjørdalen (Kjerulf 1882), and especially Meraker (Kjerulf 1883), over the mountains Volokleppen, Storfjell, Sonlifjell, Mannfjell, and Fonnfjell to Gudå in the Meråk valley, and from here over the lakes Fundsjøen and Færen to Hermansnasen. Further to the north the amphibolite injections are proceeding, after the geological map of G. Holmsen (1919), to Hyllfjell and Fagerlifjell in Verdal, and farthest north to Skjækerhatten, at 64° 1′ N.

To the south of the area of the present map, the amphibolite injection zone can be followed, from the general map of G. Holmsen (1915) and our own unpublished observations, over Gruvehøgda (at the Harsjø mine) to Langen and the Vingelen mine, at 62° 26′ N. Possibly this zone proceeds also further to the south and southwest, to the geological map Foldal (W. Marlow 1935). The hornblende schists of Marlow at the Foldal mines represent, from observations by the present author, intrusive amphibolites of the same types as further to the north. Whether they represent the present zone of injection is, however, undecided.

As to the question of the existence of effusive rocks in this southeastern part of the Trondheim area, the occurrence of basic lavas has been suggested by C. Bugge (1910 p. 23) at Fredrik IV (Vang-røfta) mine on the topographical sheet Røros, in or near the present amphibolite zone. The pillow-like jointings at this locality, being from the description observed in tectonic strongly deformed chlorite schists, are, however, not very suitable as to a definite ascertainment of the rocks in question as effusives.

The only traces of effusive material from these southeastern areas found by the present author, is the occurrence of well preserved grains of effusive basic rocks in slightly metamorphosed felspar bearing sandstones near the Kongens mine in the Røros area. These sands, may, however, have been transported a long way. The stratigraphical position of these beds is not decided, provisionally they are, however, reckoned to horizons below the injection zone discussed at present.

Black shales and graphite, possibly representing or being connected with the *Dictyonema* shale, are observed in several localities in or near the Fongen injection zone. G. Holmsen (1915 p. 21) mentions an occurrence of graphite, once mined, at Langen on the sheet Røros, whereas J. C. Hørbye (1861 p. 221) indicates graphite to the east of Melshogna, not seen by himself. Hans Reusch (1896 p. 34) mentions black alumen shale to the west of the Lillefjell mine on the sheet Essandsjø, compare also the paper by C. W. Carstens (1920 p. 60). Further to the north, G. Holmsen (1919) describes black alumen shales, as key horizons on both sides of the amphibolite zone; it is tempting to correlate these shales with the shales near Nordaunevoll.

Black shales, partly developed as alumen shales, play, at all, no insignificant role in the central Trondheim area. In the environments of the southern part of Budal they occur in extension, after Th. Kjerulf (1871). Also further to the west, e. g. in the Soknedal, in the suggested anticline to the east of the Støren effusive greenstone, black shales are occurring, after C. Bugge (1910), also being observed by the present author. It seems at present reasonable that at least some of these extremely carbonaceous shales, perhaps partly contemporaneous with the *Dictyonema* shale, may be placed rather far down in the stratigraphical series.

The Metamorphism of the Black Shales.

It is an interesting fact that apparently almost non-crystallized shales, viz. the *Dictyonema* bearing bed 6 at Blåhénbekken, is occurring in an area of rather strong metamorphism. These shales are interbedded with biotite and clinozoisite bearing mica schist. It can not be doubted that these sediments all have been exposed to about the same temperature and pressure conditions.

As to the size of the grains in the groundmass of these sediments, it may be referred to the photographs Pl. Fig. 1 (×45!), 2, 3, and 4, the former containing carbonaceous matter in profusion, the latter being without carbonaceous matter at all, and the other representing intermediate stages. It seems obvious that the grain size of the groundmass in a general way is growing with decreasing content of carbonaceous matter.

It is reasonable to assume that the contact planes between the growing crystals in the groundmass were more or less covered with carbonaceous matter, which impeded the reactions between the solid phases. Reference may also be made to an earlier discussion by the present author (1927 p. 198, 483—484) of this question.

This interpretation being, in the opinion of the author, acceptable as to the general increasing of the grain sizes and the congregation crystallization of the groundmass, it is obvious that it does not suffice as to the porphyroblasts. As regards the formation of the porphyroblasts, it is evident that diffusion in solid phase must play a very prominent role. Regarding the diffusion in solid phase, and solid phase reactions on the whole, it may be be referred to the interesting recent treatment of this topic from a chemical point of view by J. A. Hedvall (1938).

One may ask, what is the effect of the carbonaceus matter in respect to the formation of the porphyroblasts. It is called attention to one observation, illustrated by the photographs Pl. Fig. 5 and 6, representing two parts of one and same thin section. The amount of muscovite, as porphyroblasts, may be of the same order in both instances, the muscovite crystals being, however, much larger and fewer in the part of the rock containing carbonaceous matter in greatest quantity. This indicates that the centres of crystallization were fewer, the richer the rock was in carbonaceous matter, whereas the diffusion velocity may have been fairly unaffected. It may also be referred to the large but scattered porphyroblasts of actinolite in the carbonaceous shale from Blåhénbekken, compare Pl. Fig. 2. Also the well known occurrences of large andalusite (chiastolite) porphyroblasts in certain extremely carbon rich and fine grained argillaceous sediments demonstrates, indeed, the fewness of crystallization centres in these rocks.

It seems, therefore, that finely dispersed carbonaceous matter in great quantity, more or less is impeding also the formation of crystallization centres in rocks. The assumption of such a partly "killing" of the crystal germs by carbonaceous matter, do at least account for the present observations.

One further observation as to the formation of the porphyroblasts may be pointed out. The muscovite as well as the actinolite porphyroblasts are mostly filled with carbonaceous matter, except for the margin principally of the cleavage planes, these being clear and unclouded, and in addition surrounded by a very narrow rim of clear quartz without carbonaceous matter. In this way at least the planes with the strongest and densest point groups are kept clear from the carbonaceous matter, compare here the recent discussion of the porphyroblast problem by Pentti Eskola (1939). As to the muscovite porphyroblasts, they sometimes exhibit sand-glass structures (vide Pl. Fig. 5), indicating that the carbon particles are "pushed away" from the cleavage planes, being allowed, however, to enter into the crystal parallel to the latter. The present porphyroblasts of actinolite and muscovite are similar to the well known porphyroblasts of andalusite (chiastolite), chloritoid etc.

As to the preservation of the fossils at the Blåhénbekken locality, two different circumstances are considered of importance. First, the carbonaceous matter, which impeded the congregation crystallization of the rock and kept it fine grained. Next, the insignificant stress, indicated by the arrangement in all directions of the mica, compare Pl. Fig. 4 and especially and Pl. Fig. 5 and 6. The graptolites are somewhat deformed, as observed by Leif Størmer, the rocks have, however, escaped the strong partial movements along the bedding planes, and the formation of crystallization schistosity, with mica or graphite on the bedding planes. This may again be ascribed the position immediate to the large Fongen gabbro massiv, which has protected the rocks from the larger stresses.

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Explanation to the plate.

All photographs are taken with one nicol. Anker Iversen phot.

Fig. 1. Black *Dictyonema* bearing shale, bed no. 6 from Blåhénbekken. With carbonaceous matter in profusion, quartz, and extremely small flakes of sericite. The white vein to the left represents a tectonic jointing filled with muscovite. × 45.

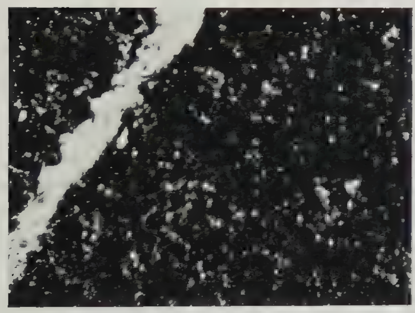
» 2. Black actinolite porphyroblast shale, bed no. 7 from Blåhenbekken. The white knife-formed line represents the rim of an actinolite porphyroblast, filled with carbonaceous matter. Not separated from this margin on the photograph, appear a very narrow rim of clear quartz grains. The groundmass contains quartz and small flakes of sericite. × 25.

» 3. Biotite schist, bed no. 3 from Blåhénbekken. Representing the groundmass of the rock, with biotite, quartz, clinozoisite, etc. and some finely dispersed carbonaceous matter. × 25.

» 4. Biotite schist from a thin bed in black shale at Hulta, near Blåhénbekken. With biotite, quartz, albite, clinozoisite, a little of an almost colourles hornblende mineral, pyrrhotite (black), etc. and a porphyroblast of calcite. Without carbonaceous matter. × 25.

» 5. Muscovite porphyroblast fels, bed no. 4 from Blåhenbekken. Muscovite porphyroblasts filled with carbonacous matter, are lying in all directions. Remark the sand-glass structure of the muscovite porphyroblast in the middle part to the right. Outside the clear margin of muscovite, a very narrow rim of clear quartz grains mostly is appearing. × 25·

» 6. Muscovite porphyroblast fels, bed no. 4 from Blåhénbekken, from the same thin section as Fig. 5. With less carbonaceous matter and smaller muscovite porphyroblasts. × 25.



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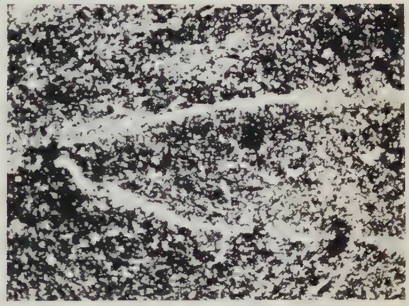

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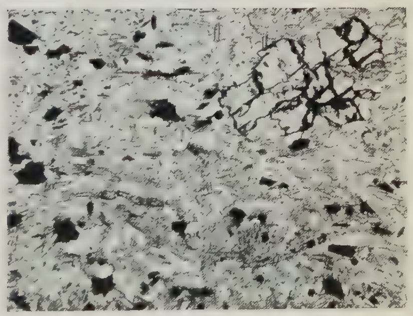

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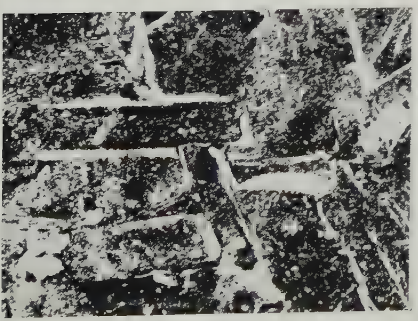

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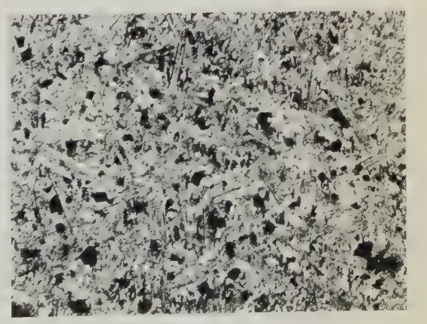

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Ms. rec. October 12, 1940.

ENRICHMENT OF LITHIUM IN NORWEGIAN CLEAVELANDITE-QUARTZ-PEGMATITES

BY

IVAR OFTEDAL

Abstract. All the Norwegian cleavelandite-quartz-pegmatites from which suitable material was available are shown to be enriched in lithium. In nearly all of them is found a brownish mica related to zinnwaldite and containing more than 1 %, in extreme cases more than 3 %, Li_2O. Other Li-rich minerals (petalite, spodumene, amblygonite &c) have so far not been observed in these deposits.

Minerals containing appreciable amounts of lithium appear to be particularly rare in Norway. A real lithium mica from Lille Årøy in the Langesundsfjord has been described by W. C. Brøgger.[1] The percentage of Li_2O in this mica is not given by Brøgger, as the material available was insufficient for a chemical analysis. By the method described below I found that the mineral must contain a percentage of Li_2O similar to that of the polylithionite from Kangerdluarsuk in Greenland, which is about 9 %.[2] This is still the Norwegian mineral with the highest known content of Li, but it is extremely rare and therefore does not contribute appreciably to the amount of Li present in the Langesundsfjord pegmatites. So does, however, the lepidomelane, which occurs in large quantities. L. W. Strock[3] found in the lepidomelane from Låven nearly 0.7 % Li_2O. My own results agree well with this figure. At the same time they show that lepidomelane from other localities in the Langesundsfjord may be somewhat poorer in Li_2O.

During spectrographic examination of minerals from the collections of the Mineralogisk-geologisk Museum in Oslo I found that also micas from certain Norwegian granite pegmatites show considerable contents of Li. These pegmatites are all of the (hydrothermal-pneumatolytic) cleavelandite-quartz type. The examined material has been collected and described by H. Bjørlykke.[1] As his investigations were carried out by means of X-ray spectral analysis he could not, of course, detect contents of Li in the minerals. As the presence of lithium mica is to be expected in cleavelandite-quartz-pegmatites[2] Bjørlykke also examined the colouring of the flame produced by a lilac coloured mica from such of deposit (Birkeland 2, Iveland), with negative result.[3] The optical spectograms confirm that this particular mica is poor in Li, in fact not richer than ordinary muscovites. The spectograms of other (brown to greenish) micas from similar deposits, however, show very strong lines of Li, and the carbon arc gives a very conspicuous red light during the first few seconds of the evaporation of these micas. This behaviour is distinct from that of all the examined ordinary micas (muscovites, biotites, phlogopites), the spectograms of which show only very weak lines of Li. The enrichment of Li in micas of Norwegian cleavelandite-quartz-pegmatites thus being recognized, it was found of interest to attempt a quantitative spectrographic determination of the percentages of Li_2O in these micas. As it is of importance that the standard mixtures should possess as nearly as possible the same properties as the examined minerals, they were in this case prepared by mixing together ordinary muscovite (containing less than 0.1 % Li_2O) and a lithium mica whose content of Li was known with some certainty.[4] For such a lithium mica was chosen the above mentioned polylithionite from Kangerdluarsuk, which, according to the published analyses, contains about 9 % Li_2O. Of course it can not be taken for granted that the particular sample used contains exactly this amount of Li_2O, however, the standard mixtures obtained were chequed by means of spectra of lepidolites (Rozna, Mähren and Paris, Maine) and zinnwaldite (Zinnwald), for which a number of analyses are found in the literature, and a fairly good agreement was found. Therefore these standard mixtures were considered fairly reliable. They were made to contain Li_2O in concentrations from about 9 % down to about 0.1 %. As it was convenient to use the Li-line 3232.7 (the lines in the visible spectrum being far too strong), the spectra were taken with the quartz spectrograph in the ultraviolet. This Li-line does not coincide with any other lines of importance in the present case. Electrodes of purified carbon were used, the cathode with a bore 4 mm deep and 1.5 mm in diameter, which was filled with the substance to be evaporated. The arc was kept burning at about 5 A for 2 minutes, the cassette and slit being open all the time. At the end of this exposure the evaporation of the sample was almost complete, only a minute bead being left in the cathode. From watching the colouring of the arc light it appears that the alkalies evaporate almost completely during the first minute, the aluminium (and iron) usually before the end of the second minute. The remaining bead usually gives no colouring of the light at all, and therefore probably consists of nearly pure SiO_2. It would seem, therefore, that the Al-lines will afford fairly reliable intensity standards for comparison with the Li-line. It is true that the percentage of Al may vary considerably in the different micas, however, it was found that the Al-lines show very nearly the same absolute intensities in all the spectra in question, and that a fairly evenly sloping calibration curve for the pair Li 3232.7—Al 3082.2 could be constructed from the spectra of the standard mixtures. This curve seems to give good values for micas poor in Mg and Fe, like the majority of the examined ones. In the case of e. g. lepidomelane a correction must be made for the low content of Al, or the Li-line may be compared with a Si-line. In order to make possible a closer intensity comparison and the construction of the calibration curve all the spectra were stepped by means of a rotating sector giving exposure times in the proportions 1 : 2 : 4 : 8 : 16 : 32 : 64. The use of the photometer was dispensed of,[1] as a visual intensity comparison in this case is sufficiently exact in view of the uncertainty as to the accurate percentage of Li in the polylithionite used for the standard mixtures. For this reason the figures given below are to be taken as approximately correct only. The following list contains the percentages of Li_2O found in micas from cleavelandite-quartz-pegmatites.

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[1] Zeitschr. Kryst. *16*, 1890, 195.

[2] J. Lorenzen, Medd. Grønland, *2*, 1881, 71 and 7, 1893, 13. This supports Brøgger's assumption that the mineral is related to polylithionite.

[3] Zur Geochemie des Lithiums. Nachr. Ges. Wiss. Göttingen, Math.-phys. Kl., Neue Folge, *1*, 1936, 185. Here is also reported that an inclusion of essexite lava in nepheline syenite pegmatite from Låven was found to contain 0.5—1.0 % Li_2O

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[1] N. G. T. *14*, 1935, pp. 226, 227, 241, 242 and N. G. T. *17*, 1937, 14.

[2] K. K. Landes, Am. Mineralogist, *18*, 1933, 50.

[3] N. G. T. *14*, 1935, 248.

[4] A series of mixtures prepared by mixing together muscovite and kunzite (assumed to contain about 7 % Li_2O) proved to be not very suitable for the determination of Li in micas. Kunzite obviously does not give off Li in the same way as do the micas during the evaporation in the carbon arc.

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[1] L. W. Strock, Spectrum Analysis with the Carbon Arc Cathode Layer, Adam Hilger, Ltd., London, 1936, 43. For a description of the spectrographic methods applied reference may be made to this paper in general.

Landås, Iveland:	
Brown mica from specimen with cleavelandite, quartz and microlite	1.5 % Li_2O
Muscovite in large flakes	0.2 » »
Olive green mica	$\ll$0.1 » »
Katterås, Iveland:	
Light greenish brown mica from specimen with cleavelandite, quartz and topaz	1.5 » »
Skripeland, Iveland:	
Light brownish mica from specimen with cleavelandite, quartz and topaz	1.5 » »
Birkeland 2, Iveland:	
Yellowish green mica from specimen with cleavelandite, quartz and topaz	0.2 » »
Lilac coloured mica from a second specimen with cleavelandite, quartz and topaz	<0.1 » » [1]
Mørkhøgda, Gjerstad:	
Yellowish mica from specimen with cleavelandite, quartz, beryl and tourmaline	0.1 » »

No other minerals containing appreciable amounts of Li were found in this material. As mentioned above, the micas from all other kinds of deposits in Norway (not counting the pegmatites of the Langesundsfjord region) seem to be poor in Li. In all of the following specimens the contents of Li_2O were found to be below or about 0.1 %.[2]

Muscovite from ordinary (magmatic) granite pegmatites	Tveit, Iveland.
	Arendal.
	Sigdal.
Mica from greisen	Glitrevann, Modum.

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[1] This mica occours in rather large quantities in the deposit and has been supposed to be a lepidolite. Bjørlykke, as mentioned above, found that it is not a lithium mica. Also Barth (N. G. U. *128 b*, 140, 1931) states that the lilac coloured mica from Birkeland is a muscovite, not a lithium mica.

[2] L. W. Strock (Zur Geochemie des Lithiums, l. c. pp. 184, 185, 187) found the following contents of Li_2O: Phlogopite 0.016 %, meroxene 0.022 %, muscovite 0.043 %, biotite (Iveland) 0.13 %.

Biotite from granite pegmatite	Tveit, Iveland. Ljosland, Iveland.
Phlogopite from apatite deposit	Ødegården, Bamble.
Biotite from micaschist	Fossingfjord, Bamble.

The muscovite from Thoreby, Varteig contains about 0,3 % Li_2O, indicating a moderate enrichment of Li in this pneumatolytic deposit. The enrichment of Li in the cleavelandite-quartz-pegmatites, which was to be expected as a consequence of the late formation of these deposits, is very clearly shown by these data. Some of the micas (see Landås, Katterås, Skripeland) are in fact nearly as rich in Li as some of the zinnwaldites from other countries. The relation to zinnwaldite is made still closer by their considerable contents of iron. On the other hand these pegmatites may at the same time contain micas which are not particularly enriched in Li (see Landås, Birkeland). In some cases the enrichment of Li in the deposit as a whole seems to be less prominent (Birkeland, Mørkhøgda).

High concentrations of Li in the micas are commonly accompanied by relatively high contents of Rb and Cs, as can be seen in spectra taken in the visible region. This is known also from earlier examinations of lithium micas.[1] Another conspicuous feature of the Li-rich micas from the cleavelandite-quartz-pegmatites is their usually very high content of Mn as compared with e. g. ordinary muscovites, even if the contents of Fe are not essentially higher than those of the muscovites.

In addition to this material collected by Bjørlykke similar specimens very found among samples collected by Olaf Andersen in 1909 and labelled Frikstad, Iveland. As a large number of granite pegmatites are found within the area of Frikstad it is not possible to tell the exact locality. Possibly it is one of the small quarries at "Kjørka", in which cleavelandite is known to occur.[2] A brown mica, looking very like that from Landås, from a specimen consisting chiefly of cleavelandite, was examined. It was found to be still richer in Li than any of the micas listed above, the content being about 3 % Li_2O. Like the other Li-rich micas from Iveland it contains some Fe and much Mn and is obviously a zinnwaldite. Other Li-rich minerals were not found in the specimens from Frikstad. A green mica associated with ordinary albite contains not more than 0.1 % Li_2O.

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[1] See e. g. Doelter, Handb. d. Min.-Ch., II, 2, 1917, 456. Also Tl, which has been found in lepidolite, was observed in some of the spectra of Li-rich mica from Iveland, probably in concentrations of the order of magnitude 0.01 %. The contents of Ga were found to be, on the average, not higher in the Li-rich micas than in ordinary muscovites.

[2] Tom. F. W. Barth, N. G. U., *128 b*, 139, 1931.

Quite recently still another occurrence of Li-rich mica has been found in the Archaean of Southern Norway. The occurrence became known through specimens which have been given to the Mineralogisk-geologisk Museum in Oslo. So far I have not been able to examine the deposit itself; the closer description, therefore, has to be postponed until later. Here I may only mention that the mica is richer in Li than any of those from Iveland, and otherwise closely related to them. In fact it is real lithium mica, the spectrograms indicating in some samples about 4 % Li_2O. In addition it occurs in much larger quantities than the Li-rich micas from Iveland. It can be seen from the specimens that the deposit is a pegmatite of the cleavelandite-quartz type. It is to be expected that also other Li-rich minerals will be found in the deposit.

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Oslo, Mineralogisk-geologisk museum, October 1940.

Printed November 20th, 1940.

W. C. BRØGGERS LIV
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AV

W. P. SOMMERFELDT
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Pochi appunti sule' Isola d'Elba, per W. C. Brøgger & H. H. Reusch.

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Über große Enstatit-Krystalle von Kjørrestad im Kirchspiel Bamle, südliches Norwegen, aufgefunden von W. C. Brøgger und H. H. Reusch. Von W. C. Brøgger und G. von Rath. Vorgelegt in der Gesammtsitzung der Akademie 26. October 1876.

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Bonn. Received by the Crystallometric Association October 9, Read, October 27, 1876.

Proceedings of the Crystallological Society, London. Part 1 (1877), s 14—23, pl. I. Utkom også som særtrykk med egen pag.: 10 s.

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Ueber große Enstatit-Krystalle. Aufgefunden von W. C. Brøgger und H. H. Reusch bei Kjörrestad im Kirchspiel Bamle, südliches Norwegen. Von W. C. Brøgger und G. vom Rath.

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Om Trondhjemsfeldtets midlere afdeling mellem Guldalen og Meldalen. (Indberetning til Chefen for den norske geologiske undersøgelse om reiser sommeren 1875 og 1876.) Med en kartskisse, profiler og to plancher. 28 s, pl I—II, 2 kart.

Christiania Videnskabs-Selskabs Forhandlinger 1877. No 2. Chr.a 1878. Utkom også særskilt.

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Om Paradoxidesskifrene ved Krekling. (Indberetning til Chefen for den norske geologiske undersøgelse, prof. Dr. Th. Kjerulf, om reiser sommeren 1877). Med 6 lithograferede plancher.

Nyt magazin for naturvidenskaberne 24 (1878), s 18—88, tabel, pl I VI. Utkom også som »Separataftryk« 72 s, pl, tab I—VI.

Untersuchungen norwegischer Mineralien. [I] (1. Das Krystallsystem des Mosandrit. 2. Das Krystallsystem des Astrophyllit. 3. Ueber ein neues Vorkommen von Thomsonit (von Låven).)

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Neues Jahrbuch für Mineralogie. Stuttgart 1879, s 566–567. Utkom også som »Separat-Abdruck«.

(Hilsen til Kjøbenhavns Universitet i Anledning af dets Firehundredaarsfest Juni 1879 fra de norske Studenter.)

Beretning om Kjøbenhavns Universitets Firehundredaarsfest Juni 1879. Udg. efter Konsistoriums Foranstaltning af Edvard Holm. Kbhavn 1879, s 65—66.

Untersuchungen norwegischer Mineralien. II. 4. Zoisit (Thulit) von Souland, Norwegen. 5. Ueber die Krystallform des Kjerulfin. 6. Natrolith von Aró (?). 7. Ueber Aeschynit von Hitterø, nebst einigen Bemerkungen über die Krystallform des Euxenit und des Polykras.

Zeitschrift für Krystallographie und Mineralogie 3 (1878 79), s 471—487, pl XI—XIII. Utkom også som »Separat-Abdruck« med bibehold av tidsskriftets pag.

Atakamit von Chile. (Mit Taf XI, Fig. 1—3.)

Zeitschrift für Krystallographie und Mineralogie 3 (1878 79), s 488—491, Taf XI. Utkom også som »Separat-Abdruck« med bibehold av tidsskriftets pag.

Zwei Hüttenerzeugnisse. (1. Krystalle einer Legirung von Blei und Silber, von Kongsberg. 2. Krystalle einer Schwefelverbindung von Kupfer und Eisen, von Röraas.)

Zeitschrift für Krystallographie und Mineralogie 3 (1878 79), s 492—495, Taf XI. Utkom også som »Separat-Abdruck« med bibehold av tidsskriftets pag.

Über Olivinfels von Söndmöre.

Neues Jahrbuch für Mineralogie 1880 II, s 187—192. Dat. 30. nov. 1879. Utkom også i »Separat-Abdruck« med bibehold av tidsskriftets pag.

1880.

Norske apatitforekomster. (Omarbeidelse og udvidelse af den i Zeitschrift der Deutschen geologischen Gesellschaft 27 (1875) trykte avhandling af W. C. Brøgger og H. H. Reusch.)

Nyt magazin for naturvidenskaberne 25 (1880), s 255—300.

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(Om smudsig nyfallen Sne paa Selø.) (Sign.: W. C. Br.)

Naturen Kra. 5 (1881), s 47.

Nogle bemærkninger om pegmatitgangene ved Moss og deres mineraler.

Geologiska föreningens i Stockholm förhandlingar 5 (1881), s 326—376, tafl 13. Utkom også i »Aftryck« med bibehold av tidsskriftets pag.

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Die silurischen Etagen 2 und 3 im Kristianiagebiet und auf Eker, ihre Gliederung, Fossilien, Schichtenstörungen und Contactmetamorphosen. Universitätsprogramm für 2. Sem. 1882. Kra. 1882. 4° Bl, VIII s, 376 s, Tab I—XII [mit] Erklärung der Tafeln, Profil.

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Die Mineralien der Pegmatitgänge bei Moss.
Neues Jahrbuch für Mineralogie 1883 I, s 80—81. Dat. 6. okt. 1882. Utkom också i »Separat-Abdruck« 1 upg. s.

Ueber Krystalle von Thorium. (Hierzu Taf VIII, Fig 3—5.)
Zeitschrift für Krystallographie und Mineralogie 7 (1883), s 442—446, Taf VIII. Utkom også som »Separat-Abdruck« med bibehold av tidsskriftets pag.

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Bihang till K. Svenska Vet.-akad. handlingar. Bd 8. N:o 5. Meddelanden från Stockholms Högskola. N:o 1. 8 s, pl.

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Om uranbegerts og xenotim fra norske forekomster. (Forelöbig meddelelse.)
Geologiska föreningens i Stockholm förhandlingar 6 (1882 och 1883), s 744—752. Utkom også i »Aftryck« med bibehold av tidsskriftets pag.

(Yttrande ang. Deichmann Branths föredrag om Geologiska forhold i Jylland.)
Förhandlingar vid de skandinaviska naturforskarnes tolfte möte i Stockholm 1880. Sth. 1883, s 281.

Spaltenverwerfungen in der Gegend Langesund—Skien.
Nyt magazin for naturvidenskaberne 28 (1884), s 253—419, pl, kart. Utkom også som »Separat-Aftryk«. Chra. [u. år] P. T. Mallings Boghandel (G. Kr. Joh.s Parmann) med bibehold av tidsskriftets pag.

Om etagerna 2 och 3 inom Kristiania silurbäcken. Föredrag.
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(Om krystallers isomorfi og morfotropi.) Copie eines Briefs an H. Rosenbusch 4. Juli 1883.
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Om Kristaller af Beryllium och Vanadium. Af W. C. Brøgger och Gust. Flink.

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Ueber Krystalle von Beryllium und Vanadium. Von W. C. Brøgger und Gust. Flink. Mit Taf VI und 2 Holzschnitten.

Zeitschrift für Krystallographie und Mineralogie 9 (1884), s 225—235. Taf VI; 236—237: Nachtrag [von] Otto Pettersson.

Om katapleitens tvillinglove.

Geologiska föreningens i Stockholm förhandlingar 7 (1884 och 1885), s 427—434. Utkom også som »Aftryck« med bibehold av tidsskriftets pag.

Om en ny konstruktion af et isolationsapparat for petrografiske undersøgelser.

Geologiska föreningens i Stockholm förhandlingar 7 (1884 och 1885), s 417—427, tafl 11. Utkom også som »Aftryck« med bibehold av tidsskriftets pag.

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Kristianiafjordens bildning. Föredrag med diskussion.

Geologiska föreningens i Stockholm förhandlingar 7 (1884 och 1885), s 473—476.

Forelöbig meddelelse om to nye norske mineraler, Låvenit og Cappelenit. (Med kemiske analyser af Prof. P. T. Cleve.)

Geologiska föreningens i Stockholm förhandlingar 7 (1884 och 1885), s 598—602. S 600—2 av P. T. Cleve. Utkom også som »Aftryck« med bibehold av tidsskriftets pag.

Ueber die Ausbildung des Hypostomes bei einigen skandinavischen Asaphiden. Mit drei Tafeln. Der K. Schwed. Akad. der Wissensch. vorgelegt 10. Juni 1885. Sth 1886. 78 s, Tab I—III.

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Referater i Zeitschrift für Krystallographie und Mineralogie 10 (1885), s 493: E. Erdmann: Farbenänderung am Feldspath in Folge der Einwirkung des Lichtes. 494—496: W. C. Brøgger: Einige Betrachtungen über die Pegmatitgänge bei Moss und ihre Mineralien. 496—498: W. C. Brøgger: Uranpecherz und Xenotim von norwegischen Vorkommnissen. Joh. Lorenzen: Untersuchung eines krystallisirten Uranpecherzes von Moss. C. W. Blomstrand: Ueber ein Uranmineral aus der Gegend von Moss und über die natürlichen Uranate im Allgemeinen. 498—503: W. C. Brøgger: Ueber die Feldspathgruppe (Die silurischen Etagen 2 und 3 im Kristianiagebiete und auf Eker.); 503—504:

W. C. Brøgger: Vorläufige Mittheilung über zwei neue norwegische Mineralien, Låvenit und Cappelenit. 504: W. C. Brøgger: Ueber die Zwillingsgesetze des Katapleït. 504—505: A. E. Nordenskiöld: Uransilicat von Garte Feldspathbruch bei Arendal. 505—506: A. Sjögren: Allaktit, ein neues Manganarseniat von Mossgrufvan in Nordmarken; Allaktit, ein neues Mineral von Nordmarks Gruben — L. J. Igelström: Neue Mineralien von Nordmark, Wermland — E. Bertrand: Krystallform des Aimafibrit und Aimatolith. — L. J. Igelström: Aimatolith und Aimafibrit, zwei neue Mineralien von Nordmarks Eisengruben in Wermland. — Joh. Lorenzen: Rothes Arsenikmineral (Aimatolith) von Nordmarken — L. J. Igelström: Manganostibiit, Aimatolith und Aimafibrit, drei neue Mineralien von Mossgrufvan in Nordmarken. — Hj. Sjögren: Krystallographische Studien 8: Allaktit von Nordmarken. — A. Sjögren: Neue Arseniate von Mossgrufvan in Nordmarken — Hj. Sjögren: Diadelphit, Synadelphit, Hämafibrit; Hj. Sjögren: Ueber das Vorkommen und die Paragenesis der Manganarseniate von Nordmarken. 506—507: Hj. Sjögren: Ueber die Krystallform und die physikalischen Eigenschaften des Graphit. 507—508: Hj. Sjögren: Bleiglanz mit oktaedrischen Durchgängen von Nordmarks Gruben in Wermland. 508: Hj. Sjögren: Untersuchung eines Opals aus der Gegend von Nagasaki in Japan. 509—510: A. Sjögren: Ueber die chemische Zusammensetzung und die Constitution des Katapleït. 510: A. Sjögren: Arsennickel, ein für Schweden neues Mineral, von der Kogrube bei Nordmarken. 510—511: Fr. Eichstädt: Anomit von Alnö, in Vesternorrland. 511: Fr. Eichstädt: Kämmererit von Norbotten in Schweden. 511—512: Mats Weibull: Mineralogische Notizen. 512—515: Mats Weibull: Das Mineralvorkommen bei Vester-Silfberg. 515—516: L. J. Igelström und E. Bertrand: Hillängsit, ein neues Mineral von Hilläng in Dalarne. 516—517: L. J. Igelström: Berzeliit von Nordmarks Gruben in Wermland — V. Lindgren: Noch einige Bemerkungen über den Berzeliit. 517: L. J. Igelström: Concentrisch strahliger Apophyllit von Nordmarks Eisengruben in Wermland. 517—518: L. J. Igelström: Gediegenes Wismuth und Wismuthglanz von Sörberg's Kupferschurf in Säfsens Kirchspiel, Dalarne; gediegenes Wismuth und Scheelit von Nordmarks Grube in Wermland. 518: L. J. Igelström: Krystallisirter Albit und Titanit von der gr. Mörkhultsgrube in Philipstads Bergdistrict; Igelströmit von Knipp-grufvan, Ludvika Kirchspiel, gr. Kopparbergs Bezirk. 518—519: L. J. Igelström: Xanthoarsenit, ein neues Mineral von Sjögrufvan im Grythytta-Kirchspiel, Oerebro-Bezirk. 519: L. J. Igelström: Manganoxydul-Arseniate von Långvik, Grythytta-Kirchspiel, Oerebro-Bezirk, Schweden. 519: L. J. Igelström: Manganostibiit, ein neues Mineral von Nordmarks Gruben in Wermland. 519—521: L. J. Igelström: Manganmineralien von den Stålmalmsgruben, Gåsborns Kirchspiel, Wermland. 521: L. J. Igelström: Empholit, ein neues Mineral von Horrsjöberg in Wermland. 521—522: L. J. Igelström: Krystallisirter Rutil von Horrsjöberg in Wermland. 522: L. J. Igelström: Einige Bemerkungen über ein Persbergit genanntes Mineral. 522: A. G. Högbom: Ueber die Natrium-Doppelwolframate der seltenen Erden.

1886.

Ueber die Bildungsgeschichte des Kristianiafjords. Ein Beitrag zum Verständniss der Fjord- und Seebildung in Skandinavien.
Nyt magazin for naturvidenskaberne 30 (1886), s 99—231, kart. Utkom også som »Separat-Abdruck«. 135 s, kart.

(Forordet) til A. Ch. Edgren-Leffler: Ur lifvet. B. 4. En sommarsaga. 1. Stholm 1886.
S (4): »Till herr professor Brogger, som haft den godheten att hjälpa mig med det norska korrekturet, hembär jag hermed min varma tacksägelse.«

(Innlegg i diskusjonen efter Gerard De Geers foredrag Om ett konglomerat inom urberget vid Vestanå i Skåne.)
Geologiska föreningens i Stockholm förhandlingar 8 (1886), s 60—62.

Om alderen af Olenelluszonen i Nordamerika.
Geologiska föreningens i Stockholm förhandlingar 8 (1886), s 182—213. Utkom også som »Aftryck« med bibehold av tidsskriftets pag.

Om de forskjellige Eruptiver paa Strækningen Mjøsen—Langesundsfjorden. Foredrag.
Forhandlinger ved de skandinaviske Naturforskeres 13. Møde i Christiania 7—12. Juli 1886. Chra. 1887, s 77.

Ordning af mikroskopiske Præparater. (Foredrag.)
Forhandlinger ved de skandinaviske Naturforskeres 13. Møde i Christiania 7.—12. Juli 1886. Chra. 1887, s 83—84.

Om Kristianiafjordens Dannelse. [Resumé av] Foredrag paa 1. alm. Møde under Naturforskermødet i Kristiania.
Naturen Kr.a 10 (1886), s 111—120. Utkom også som »Separataftryk«. 9 s 4o.

(Innlegg i diskusjonen efter Svedmarks foredrag Om de orografiska förhållandena i trakten omkring Norrtelge.)
Geologiska föreningens i Stockholm förhandlingar 8 (1886), s 381.

(Beretning om Mineralogisk-geologiska institutet og fortegnelse over Brøggers forelesninger ved Stockholms högskola vårterminen 1882—høstterminen 1885.)
Stockholms högskola. Styrelsens berättelse för tiden till 1885 års slut. S 16—25, 70—77.

1887.

Berättelse om undersökningar öfver malmförekomsten vid Klefva grufva. Af W. C. Brögger och J. H. L. Vogt. Stkholm 1887. 19 s, pl.
På omslaget: Lessebo bolag. Klefva nickelgrufva.

Geologisk kart over øerne ved Kristiania.

Nyt magazin for naturvidenskaberne 31 (1890) s 162—195, + Geologisk kart over øerne ved Kristiania (Etagen 4). På grundlag af kart over Kristiania havnedistrikt optaget 1884 og 1885 af W. C. Brøgger. Utkom også som »Separataftryk« 36 s, kart. Kr.a 1887. P. T. Mallings boghandels forlag (G. Kr. Johs. Parmann).

Om »Eudidymit«, et nyt norsk mineral. Foreløbig meddelelse.

Nyt magazin for naturvidenskaberne 31 (1890), s 196 -199. Utkom også som »Separataftryk« med bibehold av tidsskriftets pag.

(Innlegg i diskusjonen efter Santessons foredrag Om Nickelförekomsten vid Klefva.)

Geologiska föreningens i Stockholm förhandlingar 9 (1887), s 56.

Förslag om systematisk undersökning af jordskalf inom Sverige.

Geologiska föreningens i Stockholm förhandlingar 9 (1887), s 213.

(Innlegg i diskusjonen efter Nordströms föredrag Om uppfattningen af begreppet malm.)

Geologiska föreningens i Stockholm förhandlingar 9 (1887), s 214.

Foreløbig meddelelse om mineralerne paa de sydnorske augit- og nefelinsyeniters grovkornige gange.

Geologiska föreningens i Stockholm förhandlingar 9 (1887), s 247—274. Utkom også som »Aftryck« med bibehold av tidsskriftets pag.

Om hydrargillitens tvillinglagar. Foredrag [intet referat].

Geologiska föreningens i Stockholm förhandlingar 9 (1887), s 285.

Om förekomsten af »klotgranit« i Vasastaden, Stockholm. Af W. C. Brøgger och Helge Bäckström.

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Eudidymit från Arö. Foredrag.

Geologiska föreningens i Stockholm förhandlingar 9 (1887), s 405.

Lævopimarsyrens og dextropimarsyrens krystaller.

Bihang till Kongl. svenska vetenskaps-akademiens handlingar 13 (1887—1888), Afd II. N:o 13, s 19—21.

1888.

Ueber den »Dahllit«, ein neues Mineral von Ødegården, Bamle, Norwegen. Von W. C. Brøgger und Helge Bäckström. (Mitgetheilt den 12/9 1888 durch A. E. Nordenskiöld.)

Öfversigt af Kongl. Vetenskaps-Akademiens förhandlingar. 1888. N:o 7, s 493—496. Med undertitel: Meddelanden från Stockholms Högskola. N:o 77. Utkom også som særtrykk 4 s.

Vorläufige Mittheilung über den »Hiortdahlit«, ein neues Mineral von Arö, Norwegen.

Nyt magazin for naturvidenskaberne 31 (1890), s 232—239. Utkom også som særtrykk. 8 s.

Pseudobrookit från Havredal i Norge. Foredrag.

Geologiska föreningens i Stockholm förhandlingar 10 (1888), s 11.

(Innlegg i diskusjonen efter Högboms foredrag Om lagerföljden inom Herjeådalens qvartsit-sparagmitområde.)

Geologiska föreningens i Stockholm förhandlingar 10 (1888), s 17.

Om en norsk forekomst af pseudobrookit i store krystaller.

Geologiska föreningens i Stockholm förhandlingar 10 (1888), s 21—24. Utkom også som »Aftryck« med bibehold av tidsskriftets pag.

(Grunddragen till et petrografiskt system. Framstäldt vid diskussionen af frågan »granit och gneis.«)

Geologiska föreningens i Stockholm förhandlingar 10 (1888), s 303.

(Om sänkningar på Midelhafvets botten förorsakade af jordskalf. Uttalelser i anledning av Gellerstedts foredrag Om qvartära bildningar inom Danmark och Sverige.)

Geologiska föreningens i Stockholm förhandlingar 10 (1888), s. 413.

1889.

(Innlegg efter H. Reusch's foredrag Om professor Kjerulfs vetenskapliga verksamhet.)

Geologiska föreningens i Stockholm förhandlingar 11 (1889), s 11.

(Innlegg i diskusjonen efter De Geers foredrag Om sjöbäckens bildningssätt.)

Geologiska föreningens i Stockholm förhandlingar 11 (1889), s 14.

(Innlegg i diskusjonen efter Löfstrands foredrag Om apatitförekomsterna i Norrbotten.)

Geologiska föreningens i Stockholm förhandlingar 11 (1889), s 297.

Krystallform des Iridiumpentaminchlorosulfat.

I: Palmaer: »Om iridiums ammoniakaliska föreningar«. Öfversigt af Vet.-Akad. Förh. 1889, s 355; auch Ber. d. D. chem. Ges. 1890, 23, s 3810.

1890.

Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite. Mit zahlreichen chemisch-analytischen Beiträgen von P. T. Cleve. Mit 38 Textillustrationen, 27 lithographierten Tafeln und 2 geologischen Karten.

Zeitschrift für Krystallographie und Mineralogie 16 (1890), XVIII + 235 + 663 s, lystrykk, Taf I—XXIX.

Die Mineralien der Granatgruppe. Von W. C. Brøgger und H. Bäckström. Hierzu Tafel II und 8 Textfiguren.

Zeitschrift für Krystallographie und Mineralogie 18 (1890), s 209—276, Taf II. Utkom også som »Separat-Abdruck« med omslagstitel og bibehold av tidsskriftets pag.

Ueber die morphotropischen Beziehungen des Pinakiolith und des Trimerit zu verwandten Mineralien.

Zeitschrift für Krystallographie und Mineralogie 18 (1890), s 377—385. Utkom også som »Separat-Abdruck« med bibehold av tidsskriftets pag.

(Innlegg i diskusjonen efter Högboms foredrag Om sachsiska granulitområdets geognosi.)

Geologiska föreningens i Stockholm förhandlingar 12 (1890), s 17.

(Innlegg i anledning av referat av Torells meddelelse Om apatitens förekomst inom Norrbottens län.)

Geologiska föreningens i Stockholm förhandlingar 12 (1890), s 60.

(Innlegg i diskusjonen efter Svedmarks foredrag Om apatitförande bergarter inom södra och mellersta Sverige.)

Geologiska föreningens i Stockholm förhandlingar 12 (1890), s 202.

(Innlegg i diskusjonen efter Löfstrands foredrag Om apatitgångarnes uppkomst.)

Geologiska föreningens i Stockholm förhandlingar 12 (1890), s 203.

1891.

(Fortegnelse over Brøggers forelesninger ved Stockholms högskola vårterminen 1886—høstterminen 1890 og beretning om Mineralogisk-geologiska institutionen.)

Stockholms högskola under åren 1886—1890. Berättelse afgifvet af Högskolans rektor. Stholm 1891, s. 21, 38—48.

Til Kristiania Sparebanks Direktion! [Anmodning om bidrag til Kristiania Videnskabsselskab.] 2 bl 4°.

[På forfatterens eksemplar er tilføiet: Forfattet av mig 1891 og benyttet (1891 eller) 1892, samtidig forsøgt indsamling (sammen med Gustav Storm), der resulterede i såvidt erindres 5000 kr., hvorav et tusend fra korpslæge Ring og 3000 fra Sundt i Bergen og mesteparten forresten fra selskabets egne medlemmer. W. C. Br.]

Norges vigtigste Malme (Ertser). Af W. C. Brögger og J. H. L. Vogt.
Almanak for Aaret efter Christi Födsel 1892. Chr.a [1891], s 55—63.

En undersökning öfver den naturliga ultramarinen. Af W. C. Brögger och Helge Bäckström.
Svensk kemisk tidskrift. Stholm 1891, s. 1—6.

Om udsigterne for fund af drivværdige apatitforekomster i Norrbottens gabbromassiver.
Geologiska föreningens i Stockholm förhandlingar 13 (1891), s 280—285. Utkom også i »Aftryck« med bibehold av tidsskriftets pag.

Die Mineralien der Granatgruppe. (Hierzu Tafel II und 8 Textfiguren.) Von W. C. Brögger und H. Bäckström.
Zeitschrift für Krystallographie und Mineralogie 18 II & III (1891), s 209—276, Taf II. Utkom også som særtrykk med bibehold av tidsskriftets pag.

Sonja Kovalevski.
Skilling-Magazin Kr.a 1891, s 225 (portr.), 227—230.

(Takkeskrivelse i anledning av overrekkelsen av Murchison-medaljen.)
Verdens Gang 1891 nr 50.

»Det tertiære Menneske« fra Kaliforniens Guldforekomster.
Verdens Gang 1891 nr 89, 91.

Fra et europæisk Badested [dat. Wiesbaden, 7. Juni].
Verdens Gang 1891 nr 142.

Den elektrotekniske Udstilling. Nogle Rejseindtryk. (Frankfurt.)
Verdens Gang 1891 nr 186, 192, 196, 210, 227, 238, jfr 242 av S.; jfr. Teknisk ugeblad 1891, s 164—165: Den tekniske høiskole — og aluminium.

(Brøggers beretninger om sin undervisning ved Det kgl. Frederiks universitet (forelesninger, ekskursjoner, tiltredelsesforelesning 9. febr. 1891), se Universitetets årsberetninger 1891—1917.)

Hr. Redaktør! [I anledning av Vårt Land's artikel 1891 9/11 »Svensk välvilja besvarad med norska ohöfligheter« foranlediget ved Studentersamfundets diskusjon om flaggsaken 31. okt. 1891.]
Verdens Gang 1891 nr 275; jfr Aftonbladet 1891 16/11, Göteborg Handels & Sjöf. Tid. 1891 17/11; Sundsvallsposten 1891 14/11; Svenska Dagbl. 1891 17/11; Vårt Land 1891 17/11.

(Bemærkninger om Jernnikkelkisens krystallografiske Stilling. Knyttet til et Foredrag af Vogt i Videnskabs-Selskabets Møde 6. Novbr. 1891. Intet Referat.)
Oversigt over Videnskabs-Selskabets Møder i 1891. Chr.a 1892, s. 43.

(Et Exempel paa regelmæssig Sammenvoxning af Magnetit og Pyroxen. Meddelelse i Videnskabs-Selskabets Møde 20. Novbr. 1891. Intet Referat.)
Oversigt over Videnskabs-Selskabets Møder i 1891. Chr.a 1892, s 43.

1892.

Medredaktør av Nyt magazin for naturvidenskaberne fra bind 32, 1892 til sin død.

Nyttige norske Mineraler. Af W. C. Brøgger og J. H. L. Vogt.
Almanak for Aaret efter Christi Fødsel 1893, Chr.a [1892], s 52—56.

(Uttalelse om undervisningen i naturfag i den høiere skole. Undertegnet: W. C. Brøgger. A. Blytt, R. Collett, G. O. Sars. Johan H. L. Vogt, R. Waage.)
Udkast til en forandret ordning af det høiere skolevæsen. Af den ved kgl. res. av 3/9 1890 til en revision af bestemmelserne om det høiere skolevæsen nedsatte kommission. Kr.a 1891. [Bilag] Uddrag af skolernes besvarelser af de af kommissionen stillede spørgsmaal. Chr.a 1892, s 161—187: Universitetets erklæringer om kommissionens udkast, s 175—176: W. C. Brøggers uttalelse.

Rejseskisser og Rejsetanker [dat. Neapel, Januar].
Verdens Gang 1892 nr. 21.

Museer. Rejsebrev [dat. Neapel, januar].
Verdens Gang 1892 nr 30.

Af et Brev.
Verdens Gang 1892 nr 39.

Fra de lipariske Øer. Rejseskisser [dat. Stromboli 20 Januar 1892; Palermo. Februar 1892].
Verdens Gang 1892 nr 44, 60, 82, 84, 86.

(Svar i Anledning af en Artikel i Dagbladet 1892 23/3: En svensk Statsraad om norske Regjeringer.)
Verdens Gang 1892 nr 72.

(Om de ældste Eruptiver i Kristianiafeldtet. Foredrag i Videnskabs-Selskabets Fællesmøde 25. Marts 1892.)
Oversigt over Videnskabs-Selskabets Møder i 1892. Chr.a 1893, s 5.

Verdens Universiteter.
Verdens Gang 1892 nr 87, 88, 92.

Fra Vesuv og Somma. Reiseskisser fra Vinteren 1892.
Aftenposten 1892 nr 221, 226, 234.

Indstilling fra den af Arbeidsdepartementet nedsatte komite angaaende Norges geologiske undersøgelser.

Trykt i Sortingsforh. i Hovedp. VII, kap. 3 for 1894 (D. 1 b), s 11—25. W. C. B. var formann i komiteen nedsatt $^{5}/_{5}$ 1892 som skulde behandle spørsmålet om forholdet mellem Den geologiske undersøkelses innsamlinger og Universitetets mineralkabinett og om en plan for undersøkelsene for en lengre fremtid, herunder særlig om man skulde fortsette med den systematiske utgivelse av de geologiske karter i den anvendte målestokk.

Indberetning fra Kommissionen til Undersøgelse af de teknisk-geologiske Forhold ved Bergensbanens vestenfjeldske Alternativer. [Kr.a u. år] 39 s, 3 pl 4°.

Kommisjonen var nedsatt efter anmodning fra Arbeidsdepartementet til Jernbanestyrelsen ved skrivelse av $^{28}/_{7}$ 1892. W. C. B. var kommisjonens formann.

Sundtit, et nyt mineral fra Oruro i Bolivia. (Fremlagt i mødet 9. december 1892.) 11 s.

Christiania Videnskabs-Selskabs Forhandlinger for 1892. No. 18. Utkom også særskilt.

1893.

Lagfølgen på Hardangervidda og den såkaldte »høifjeldskvarts«. (Med 31 figurer i texten og et tysk resumé.) Kr.a 1893. 2 bl, 142 s. Norges geologiske undersøgelse. No. 11.

Norges vigtigste nyttige Bergarter. Af W. C. Brøgger og J. H. L. Vogt.

Almanak for Aaret efter Christi Fødsel 1894. Chr.a [1893], s 52—57.

After. Agalmatolit. Agāt. Agrécola, Georg. Agrikolit. Ainalit. Airy's Spiraler. Akantit. Akse. Alabast. Alaskait. Algodonít. Alipít. Alisonít. Allagít. Allaktít. Allemontít. Allofān. Alloklas. Allokroít. Allopalādium. Allotigen. Allotriomorfi. Allnandít. Alnöit. Alstonít. Altaít. Alumian. Aluminit. Alumocalcit. Alunit. Alurgit. Alvit. Amausít. Amblygonít. Amesit. Amfisylenskifer. Amfodelít. Ammiolít. Amorf. [Jfr Zeitschrift für Krystallographie und Mineralogie 25 (1896), s 427—428 av M. Bäckström.] Anagenit. Analcīm. Anătas. Andalusít. Anderbergit. Andrewsít. Anglesit. Anharmonisk Forhold. Anhydrit. Ankerit. Annabergit. Annit. Anthrakonit. Anthrakoxēn. Anthrax. Antillit. Antimōnarsēn. Antimonarsennikkel. Antimonblende. Antimonblomst. Antimonglans. Antimonnikkel. Antimonofyllit.

Antimonokker. Anflerit. Apatelit. Apatit. Aragonit. Aragotit. Ardennit. Arequipit. Argyrodit. Arit.
Salomonsens store illustrerede Konversationsleksikon. B. 1, Kbhavn 1893.

Sundtit, ein neues Mineral von Oruro in Bolivia. (Mit 1 Textfigur.)
Zeitschrift für Krystallographie und Mineralogie 21 (1893), s 192—199. Utkom også som »Sonder-Abdruck« med bibehold av tidsskriftets pag.

»Lad os faa Opgjør«. To Unionsartikler.
Verdens Gang 1893 nr 5, 7.

(Om en Jernmeteorit fra Morradalen. Foredrag i Videnskabs-Selskabets Møde 24. Marts 1893.)
Oversigt over Videnskabs-Selskabets Møder i 1893. Chr.a 1894, s 7.

(Om en Formation af sure Tuffer og Tufkonglomerater vest for Alunsjøen. Foredrag i Videnskabs-Selskabets Møde 21. April 1893. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1893. Chr.a 1894, s 8.

(Jordskredet i Værdalen. Foredrag i Videnskabs-Selskabets Møde 26 Mai 1893. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1893. Chr.a 1894, s 39.
Referat i Morgenbladet 1893 29/5.

Indberetning om skredet i Værdalen [fra] W. C. Brøgger og Th. Münster.
Naturen 7 (1893), s 193—207.

Ud med Æresskillingen! [til Nansens forestående Nordpolsferd].
Verdens Gang 1893 nr 126.

I Nansens Hjem.
Verdens Gang 1893 nr 144.

Bergensbanen.
Verdens Gang 1893 nr 148, 149.

Hviler Trondhjems Domkirke paa sikker Grund?
Morgenbladet 1893 nr 308 (Svar paa en Forespørgsel fra en »Usagkyndig« i samme nr.).

The Basic Eruptive Rocks of Gran. (A Preliminary Notice.) (Printed as Manuscript for a Paper read at the Meeting of the British Association at Nottingham, Sept. 1893.) Kr.a 1893. 30 s 4°.

(Om et »naturligt System« i Petrografien. Foredrag i Videnskabs-Selskabets Fællesmøde 3. Novbr. 1893. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1893. Chr.a 1894, s 48.

(Opnevnt opponent ved dosent Niels Viggo Ussings doktordisputas 4de desbr. 1893 ved Kjøbenhavns universitet for sin avhandling: »Alkalifeldspaterne i de sydgrønlandske Nefelinsyeniter og beslægtede Bjærgarter«. Intet referat.)
Aarbog for Kjøbenhavns Universitet, den polytekniske Læreanstalt og Kommunitetet indeholdende Meddelelser for det akademiske Aar 1893—94. Kbhavn. 1895, s 517.

1894.

Die Eruptivgesteine des Kristianiagebietes. 1. Die Gesteine der Grorudit-Tinguait-Serie. Mit 4 Karten und Tafelen und 17 Figuren im Text. 1894. 4 bl, 206 s, 4 karter og pl.
Videnskabs-Selskabets Skrifter. I. Mathematisk-naturv. Klasse 1894. No. 4.

Norske forekomster af malme, nyttige mineraler og bergarter. Af W. C. Brøgger og J. H. L. Vogt. Kr.a 1894. 2 bl, 80 s.

Norges vigtigste nyttige Bergarter. Af W. C. Brøgger og J. H. L. Vogt.
Almanak for Aaret efter Christi Fødsel 1895. Chr.a 1894, s 55—62.

Arkanit. Arktolit. Astrofyllit. Atakamit. Atelestit. Atelit. Atopit. Attakolit. Augelit. Augetit. Augitporfyrit. Aurichalcit. Auripigment. Avanturin. Axinit. Azurit. Barilla de Cobre. Barkevikit. Barsowit. Barylit. Barysil. Baryt. Barytocølestin. Barytokalcit. Barytsalpeter. Basis, 5. Bastit. Bastnæsit. Bathvillit. Baulit. Bauxit. Bayldonit. Bementit. Beraunit. Berengelit. Beresit. Bergamarkit. Berlinit, 1. Berthierin. Berthierit. Bertrandit. Beryl. Berzeliit. Berzelin. Beudantit. Beyrichit. Binheimit. Binnit.
Salmonsens store illustrerede Konversationsleksikon. B. 2, Kbhavn 1894.

Bischofit. Bisilikater. Bismit. Bismutit. Bjærgkork. Bjærglæder. Bjærgmel. Bjærgmælk. Bjærgsmør. Bjærgtræ. Blaabest. Blaablyerts. Bladtellur. Blende. Blender. Blodsten. Blomstrandit. Blyertser. Blyglans. Blyglætte. Blygummi. Blødit. Bombiccit. Boracit. Boraks. Borokalcit. Boromagnesit. Boronatrokalcit. Bostonit. Botryogen. Boussingaultit.
Salmonsens store illustrerede Konversationsleksikon. B. 3, Kbhavn 1894.

(Om Katoforiter. Foredrag i Videnskabs-Selskabets Møde 26. Jan. 1894.)
Oversigt over Videnskabs-Selskabets Møder i 1894. Chr.a 1895, s 2.

The Basic Eruptive Rocks of Gran. (A Preliminary Notice.)
Quarterly Journal of the Geological Society 1 (1894), s 15—37. Utkom også som særtrykk med bibehold av tidsskriftets pag.

(»Om Neanderthal-racen og dens betydning for spørgsmaalet om menneskets stamtræ.« Foredrag i Videnskabs-Selskabets Fællesmøde 1. Mai 1894.)
Oversigt over Videnskabs-Selskabets Møder i 1894. Chr.a 1895, s 9 (intet referat).

Om Neanderthal-racen og dens betydning for spørgsmaalet om menneskets stamtræ. (Foredrag i Kristiania Videnskabsselskabs aarsmøde 1ste mai 1894.)
Nyt tidsskrift. Ny række. 2 (novbr. 1893—oktbr. 1894), s 625—655; s 656—665: Efterskrift. (Dat. Kr.a d. 20/6 1894.) Jfr. Morgenbladet 1894 nr 252: Geologien og Skriften (Red).

(Bemærkninger til J. H. L. Vogts Foredrag over Peridotiternes Sammensætning i Videnskabs-Selskabets Møde 25. Mai 1894.)
Oversigt over Videnskabs-Selskabets Møder i 1894. Chr.a 1895, s 11.

Ombord paa «Fram«. Skisse.
Verdens Gang 1894 nr 145, 146, 147, 148, 149, 151, 152.

Om Eruptivbergarterne ved Predazzo i Tyrol. Foredrag i Videnskabs-Selskabets Møde 16. Novbr. 1894.
Oversigt over Videnskabs-Selskabets Møder i 1894. Chr.a 1895, s 14.

1895.

Die Eruptivgesteine des Kristianiagebietes. 2. Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtyrol. Mit 19 Figuren im Text. 1895. 3 bl, 183 s, tabel ad p. 62.
Videnskabs-Selskabets Skrifter. I. Mathematisk-naturv. Klasse. 1895. No. 7.

Geologi. Af W. C. Brøgger og J. H. L. Vogt.
Norges land og folk. Topografisk-historisk beskrivelse med enkelte vigtigere statistiske data. V. Buskeruds amt. Kr.a 1895, s 29—40.

Columbit.
Salmonsens store illustrerede Konversationsleksikon. B. 4, Kbhavn 1895.

(Monzoniternes systematiske Stilling. Foredrag i Videnskabs-Selskabets Møde 25. Jan. 1895.)
Oversigt over Videnskabs-Selskabets Møder i 1895. Chr.a 1896, s 1.

Berglovens § 8. Af W. C. Brøgger, J. H. L. Vogt.
Dagbladet 1895 nr 69, 74, 75, 81; jfr nr 65, 70, 77, 78, 79, 80, 81, 82, 83, 85, 90 af Amund Helland; 82, 89 af Christiania Minekompani; 91.

Thoritstriden.

Morgenbladet 1895 $^{31}/_{3}$ nr 173. Af W. C. Brøgger og J. H. L. Vogt; jfr nr 121: Af Ragnvald Blakstad; nr 123; nr 129: Af Dr. Hans Reusch; nr 143: Om Skjærpning af Thorium; nr 157: Af Chr. A Münster; nr 176: Af Amund Helland; nr. 178: Af L. Schmelck; Teknisk ugeblad 1895, s 131—132; 145—146 av ingeniør Ths. Brönlund; Syn og segn 1904, s 125—129, 160—167: Torittfeberen. Minne fraa vinteren 1894—95.

Om oprettelse af et frit universitet i Bergen. Foredrag for en af Bergens museums bestyrelse indbudt forsamling den 9de april 1895. Tr. som ms. Bergen 1895. 22 s.

(Foredrag i Handelssamfundets Sal i Bergen om Oprettelse af et Universitet i Bergen.)

Aftenposten 1895 nr 233; Morgenbladet 1895 nr 237; Bergens Aftenblad 1895 $^{10}/_{4}$ nr 5101; jfr. nr 5107; Bergens Tidende 1895 $^{10}/_{4}$ nr 108, $^{1}/_{5}$; jfr Dagbladet 1898 $^{16}/_{7}$ nr 198.

(Mineralet »Brøggerit«. Fremvisning i Videnskabs-Selskabets Møde 19. April 1895.)

Oversigt over Videnskabs-Selskabets Møder i 1895. Chr.a 1896, s 7.

Adressen til Stortinget. [Anmodning om, at den indre politiske Kamp maa skydes tilside en Stund, saa at Norges folkevalgte Repræsentanter kan staa samlede til at møde de Krav, som den unionelle Tvist og Øieblikkets Alvor stiller til dem. Undertegnet bl. a. af W C. Brøgger.]

Norske Intelligenssedler 1895 $^{4}/_{5}$ nr 103.

(Innlegg i diskusjonen efter ingeniør Stenbergs foredrag om teknisk høiskole.)

Teknisk ugeblad 1895, s 127—128.

(Mindeord over James Dwight Dana i Videnskabs-Selskabets Møde 24. Mai 1895. Intet referat.)

Oversigt over Videnskabs-Selskabets Møder i 1895. Chr.a 1896, s 11.

De Ankerske Marmorbrud. (Adresse Til den kongelige norske Regjering [ang. approbasjon på salget av de Ankerske marmorleier]. Undertegnet: W. C. Brøgger, Johan H. L. Vogt [og 22 andre], dat. 10. juni 1895.)

Morgenbladet 1895 nr 332; jfr 339: Af D. Cappelen; nr 341: Af R. B.; nr 342: Af h.r.advokat Ihlen; nr 343: Til den kongelige norske Regjering. (Adresse undertegnet av 19 forretningsmenn); nr. 344: Den Ankerske Marmorforretning. Af W. C. Brøgger og J. H. L. Vogt; nr. 349: Af H. C. Smith.

(Om Granithypothesen. Foredrag i Videnskabs-Selskabets Møde 20. Sept. 1895. Intet Referat.)
Oversigt over Videnskabs-Selskabets Møder i 1895. Chr.a 1896, s 13.

1896.

Fridtjof Nansen. 1861—1893. Ved W. C. Brøgger og Nordahl Rolfsen. Med indledningsdigt af Bjørnstjerne Bjørnson. Originaltegningerne ved Chr. Krohg, Otto Sinding og E. Werenskiold. Kbh. 1896. 3 bl, portr, 350 s, bl.

Fridtiof Nansen. 1861—1893. By W. C. Brøgger and Nordahl Rolfsen. Translated by William Archer. With Numerous Illustrations and Maps. London 1896. X + 402 s, 8 portr og illustr, 3 karter.

Fridtjof Nansen. V. G. [!] Brøggera i N. Rolfsena stichotvornym vvedeniem Bjørnstjerne-Bjørnsona. Perevod s datskago A. i P. Hansen. S mnogočislennymi risunkami v tekstě i tremja geografičeskimi kartami. S. Petersb. 1896. VIII + 363 + upg s, bl, 2 karter.

Fridtjof Nansen. 1861—1893. Af W. C. Brøgger och Nordahl Rolfsen. Med bidrag af Prof., D:r Gustaf Retzius, Prof., Frih. F. Richthofen, Prof. H. Mohn, Baron Eduard von Toll, Kandidat Aksel Arstal m. fl. Originalteckningar af Chr. Krohg, Otto Sinding och E. Werenskiold. Öfversatt af Gustaf Asbrink, fil. kand. Stholm 1896. 3 bl, portr, 358 s, bl, 3 karter.

Fridtjof Nansen. 1861—1893. Von W. C. Brøgger und N. Rolfsen. Deutsch von Eugen von Enzberg. Mit Originalzeichnungen von Chr. Krohg, Otto Sinding, E. Werenskiold und photographischen Aufnahmen in Grönland von Dr. Erick von Drygalski. Berlin 1896. 478 s, bl, 3 karter.
— — 2. Aufl. 1897. 478 s, bl, 3 kart.
— — 3. Aufl. 1897. 478 s, bl, 3 kart.
— — 4. Aufl. 1898. 478 s, bl, kart.

Om anvendelse af naturlig sten i vor husbygningskunst.
Teknisk ugeblad 1896, s 93—99, 125—129; jfr 34—35, 41—43 av A. Schirmer; s 165—167, 173—174 av Henr. Lund. Utkom også som særtrykk med omslagstitel. 12 s 4⁰.

Norsk Folkemuseum.
Verdens Gang 1896 nr 70.

Til Medborgere. [Opfordring om å møte de hjemvendende polarfarere under sine faner, og til å smykke sine hus. Undert. bl.a. av W. C. Brøgger.]
Verdens Gang 1896 nr 197.

(Velkomstord til »Fram« efter driften over Polarhavet.)
Verdens Gang 1896 21/8 nr 197.

De tre Redere. Heiberg-Fearnley-Ringnæs.
Verdens Gang 1896 nr 204.

I Domkirken. [I anledning av »Fram«s tilbakekomst. Dat. Trondhjem, 30. august.]
Verdens Gang 1896 nr 205.

Kongen og »Fram«. Hvad »Fram« selv mener.
Verdens Gang 1896 nr 205.

Paa Vent efter »Fram«.
Verdens Gang 1896 nr 206.

Til det norske Folk. (Oprop til å tegne bidrag til Fridtjof Nansens Fond til Videnskabens Fremme. Undertegnet: W. C. Brøgger sammen med 26 andre.)
Morgenbladet m. fl. 1896 11. sept.

Tale for de hjemvendende Polarfarere ved Christiania Bys Middag.
Morgenbladet 1896 nr 527.

Nansens Professorat. Af W. C. Brøgger og N. Wille.
Verdens Gang 1896 nr 210.

(Om Uholdbarheden af »Kernhypothesen« og »Gefolgschafthypothesen«. Foredrag i Videnskabs-Selskabets Møde 20. Novbr. 1896.)
Oversigt over Videnskabs-Selskabets Møder i 1896. Chr.a 1897, s 15.

(Om Lakkolithbergarternes Størkningsniveau. Foredrag i Videnskabs-Selskabets Møde 4. Decbr. 1896.)
Oversigt over Videnskabs-Selskabets Møder i 1896. Chr.a 1897, s 16.

1897.

Ueber den Mossit und über das Krystallsystem des Tantalit (Skogbölit) aus Finnland. Mit 6 Figuren im Text.
Videnskabs-Selskabets Skrifter. I. Mathematisk-naturv. Klasse. 1897. No 7. Udgivet for Fridtjof Nansens Fond. Kr.a 1897, 19 s.

Ueber die Verbreitung der Euloma-Niobe-Fauna (der Ceratopygenkalkfauna) in Europa.
Nyt magazin for naturvidenskaberne 36 (1898), s 164—240.

(Innlegg i diskusjonen efter J. H. L. Vogts foredrag Om det indbyrdes kvantitative forhold mellem elementerne i jordskorpen i Videnskabs-Selskabets Møde 29. Jan. 1897.)
Oversigt over Videnskabs-Selskabets Møder i 1897. Chr.a 1897, s 2.

En Audiens hos Nikolaus II.
Verdens Gang 1897 nr 224.

Indstilling fra den af det akademiske kollegium under 21de september 1896 nedsatte komite til undersøgelse af universitetets lokaler og instituter, indsendt i september 1897. Kr.a 1897. 31 s 4°. Undertegnet: H. Heiberg, R. Collett, G. A. Guldberg, W. C. Brøgger, H. Geelmuyden, Axel Holst.

(Rapakivi i Kristianiafeltet. Meddelelse i Videnskabs-Selskabets Møde 26. Novbr. 1897.)
Oversigt over Videnskabs-Selskabets Møder i 1897, Chr.a 1897, s 21.

1898.

Die Eruptivgesteine des Kristianiagebietes. III. Das Ganggefolge des Laurdalits. Mit einer Karte, 4 Tafeln u. 5 Figuren im Text.
Videnskabsselskabets Skrifter. I. Mathematisk-naturv. Klasse. 1897. No. 6. Udgivet for Fridtjof Nansens fond. Kr.a 1898, 6 bl, 377 s, kart, 7 pl & tab.

Einleitende Bemerkungen über Fundort und Entdeckung des Meteoreisens von Morradal.
E. Cohen: Über das Meteoreisen von Morradal bei Grjotli zwischen Skiaker und Stryn, Norwegen. Videnskabsselskabets Skrifter I. Mathematisk-naturv. Klasse. 1898. No. 7. Chr.a 1898, s. 3—6.

Guld.
Salmonsens store illustrerede Konversationsleksikon. B. 8, Kbhavn 1898, s. 107—108.

Abemennesket (Pithecanthropus erectus).
Ringeren. Kr.a 1898, no 8, s 6—10, no 9 side 8—12.

Hans Rasmus Astrup (»Over Sindet Sorgen sænker«). [Sign.: W. C. B.]
Verdens Gang 1898 nr 43.

(Aktieindbydelse for Dannelse af en Torvkul-Briket-Fabrik. Undertegnet: Dr. W. C. Brøgger, Cath. Bang, G. Hartmann, Fr. Hiorth, Thomas Heftye, Axel Winge, Johan H. L. Vogt.)

Farmand. Ugeskrift for Norges Næringsveie. 8 (1898), s 178—181; jfr 158, 204, 205, 228, 378—379; jfr Aftenposten 1898 nr 324, 331, 346.

(Om Jotunstenens Alder. Foredrag i Videnskabs-Selskabets Møde 11. Novbr. 1898.)

Oversigt over Videnskabs-Selskabets Møder i 1898. Chr.a 1899, s 30—31.

(Vulkanen Etna paa Sicilien. Foredrag i Geografisk Selskab 30/11 1898.)

Aftenposten 1898 nr 891.

1899.

(Om Indlandsisen. Foredrag i Videnskabs-Selskabets Møde 27. Jan. 1899.)

Oversigt over Videnskabs-Selskabets Møder i 1899. Chr.a 1900, s 2.

Ved Sophus Lies Baare. Tale i Trefoldighedskirken 24de Februar.

Aftenposten 1899 nr 151.

(Om Brøggeritens Forhold med Hensyn til Becquerelstraaleemission. Meddelelse efter Opdrag af Ingeniør Sinding-Larsen i Videnskabs-Selskabets Møde 21 April 1899.)

Oversigt over Videnskabs-Selskabets Møder i 1899. Chr.a 1900, s 18.

A Sa Majesté Impériale Nicolas II.

Adresse dat. Christiania le 18 Juin 1899 undertegnet W. C. Brøgger sammen med 31 andre nordmenn. Folio-Patent. — En rundskrivelse med opfordring til å undertegne denne adresse foreligger kun hektografert; overskrift: Privat, undertegnet: W. C. Brøgger, Fridtjof Nansen, udatert.

On the European Deputation.

Finland, an English Journal. 1899. No 3. Septbr.

Den europæiske Adresse til Zaren. Optegnelser og Indtryk.

Verdens Gang 1899 nr 206.

(Fortsatte Undersøgelser over Yoldialerets og Arcalerets Udbredelse i Kristianiafeltet. Meddelelse i Videnskabs-Selskabets Møde 29. Sept. 1899.)

Oversigt over Videnskabs-Selskabets Møder i 1899. Chr.a 1900, s 23.

»Norsk Marmorindustri og Hr. Professor Brøgger.«

Morgenbladet 1899 nr 892; jfr nr 868 og 1900 nr 111 av Nicolai Friis.

1900.

Norges geologi. Med 38 illustrationer og kartskisser samt et geologisk oversigtskart.

Norge i det nittende aarhundrede. Udg af W. C. Brøgger, B. Getz, A. N. Kiær, Moltke Moe, Bredo Morgenstierne, Gerhard Munthe, Fridtjof Nansen, Eilif Peterssen, Nordahl Rolfsen, J. E. Sars, Gustav Storm, E. Werenskiold. Hovedredaktører: For teksten Nordahl Rolfsen, for illustrationerne E. Werenskiold. Tekst og billeder af norske forfattere og kunstnere. B 1, Kr.a 1900, s 1—32 f°.

Videnskabelige ekspeditioner.

Norge i det nittende aarhundrede. B 1, Kr.a 1900, s 265—275.

Konglomerater i Kristianiafeltet. I. Om porfyrkonglomeratet paa ørækken Revlingen-Søstrene.

Nyt magazin for naturvidenskaberne 38 (1900), s 29—64, pl II—VIII.

»Innstilling fra komiteen [nedsatt av Kirkedepartementet under 1/5 1899 til å forberede planer for nybygning av lokaler for Universitetets naturvidenskapelige museer], dat. 28. febr 1900.«

Trykt i St prp nr 74 for 1900/01 (D 2 b), s 33—37.

»Innstilling fra [den samme] komiteen [som ovenfor], dat 28. okt. og 27. nov. 1902.«

Trykt i St prp nr 76 for 1902/03 (D 2 b), s 2—7 og 10—15.

The Principles of a Genetic Classification of the Igneous Rocks. [Referat av W. C. Brøggers forelesninger ved Johns Hopkins University, Baltimore, April 1900: George Huntington Williams Memorial Lectures on the Principles of Geology, ved H. S. Washington.]

Særtryk (s 456—490) i forf.s' efterlatte samling. Forfatteren selv betegner referatet som »meget ufuldstendigt og i flere henseender helt misvisende«

Amerikaferd.

Aftenposten 1900 nr 259.

(Om den sydskandinaviske Hævning efter Istiden. Foredrag i Videnskabs-Selskabets Fællesmøde 9. Okt 1900.)

Oversigt over Videnskabs-Selskabets Møder i 1900. Chr.a 1900, s 16.

(Mindeord over Professor Otto Torell i Videnskabs-Selskabets Møde 12. okt 1900. Intet referat.)

Oversigt over Videnskabs-Selskabets Møder i 1900. Chr.a 1901, s 15.

(Om Ædelstene. Foredrag i Haandverks- og Industriforeningens Lokale.)

Aftenposten 1900 nr 866.

Om de senglaciale og postglaciale nivåforandringer i Kristianiafeltet. (Molluskfaunan.) Af W. C. Brøgger. Med bidrag af E. B. Münster, P. Øyen o. fl. Med 19 plancher og 69 figurer i texten. Kra 1900 og 1901. XI + 731 s, tab I—XIX med bl. Forklaring, tabel. Norges geologiske undersøgelse. No 31.

1901.

Fridtjof Nansen jego žizn' i putešestirja. Po knigě V. Brøggera i N. Rolfsena, a takže po podlinnym sočinenijam putešestvennika pereveli i sostavili A. i P. Hanzen. 2-oe značitelno depolnennoje izdanie, s 138 ris v tekstě i 3 geografičeskimi kartani.` St. Peterb 1901. VIII. bl, 460 s, 4 karter.

(Den anden Isperiode. Foredrag i Göteborgs høiskole februar 1901.)
Göteborgs Handels- och Sjöfarts-Tidning 1901 nr 38 ^{14} 2, 43 A ^{20} 2; Morgenposten 1901 5. febr. Aftenposten 1901 nr 132.

(Takketale ved festen på Grand Hotel Haglund Göteborg 28. febr. 1901 efter hans forelesninger ved Göteborg høiskole.)
Aftenposten 1901 nr 154; jfr 159; Göteborgs Handels- och Sjöfarts-Tidning 1901 nr 51A $^{1}/_{3}$. Göteborgs Aftonblad 1901 1. mars.

(Om Sverdrupekspeditionens tilbakekomst. Udtalelse til Helsingborg Dagblads redaktør.)
Aftenposten 1901 nr 506.

(Overrekkelse av Universitetets adresse til University of Glasgow i anledning av dets 450-års-jubileum. Intet referat.)
Record of the Ninth Jubilee of the University of Glasgow 1451—1901. Glasgow 1901.

(Om Dannelsen af de norske Kisforekomster. Foredrag i Videnskabs-Selskabets Møde 27. Septbr. 1901.)
Oversigt over Videnskabs-Selskabets Møder i 1901. Chr.a 1902, s 25.

(Om en ny norsk Forekomst af Kuglegranit. Meddelelse i Videnskabs-Selskabets Møde 27. Septbr. 1901.)
Oversigt over Videnskabs-Selskabets Møder i 1901. Chra.a 1902, s 25.

(Mindeord over Professor A. E. Nordenskiöld i Videnskabs-Selskabets Møde 11. Okt. 1901. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1901. Chr.a 1902, s 26.

Mæcenatskab i Amerika og Europa.
Aftenposten 1901, nr 785, 798, 811, 817, 823.

Mæcenatskab i Amerika og Europa. Særaftryk af »Aftenposten«, Kr.a 1901. 24 s.

1902.

Videnskabsmand.

Forældre og børn. En bog om hjemmets opgaver af forældre og barnevenner. Udg ved Aksel Arstal. Kr.a 1902, s 519—526.

(Islands Geologi. Foredrag i Videnskabs-Selskabets Møde 24. Jan. 1902. Intet referat.)

Oversigt over Videnskabs-Selskabets Møder i 1902. Chr.a 1903, s 2.

(Meddelelse om en Undersøgelse af Bamble-Formationens Bergarter i Videnskabs-Selskabets Møde 18. April 1902.)

Oversigt over Videnskabs-Selskabets Møder i 1902. Chr.a 1903, s 10.

De naturhistoriske Museers Beliggenhed.

Aftenposten 1902 nr 240, 245.

Ved Immatrikuleringen af de nye Studenter den 2den September 1902. Tale.

Aftenposten 1902 nr 626, 627.

Ved immatrikuleringen af de nye studenter den 2den september 1902. Tale.

Nordisk universitets-tidsskrift. Göteborg 3 (1902—1903), s 71—85. Optrykt i »Studentene fra 1902«, Oslo 1927, s 12—19.

Abel-Jubilæet. Aabningsmødet den 5te September. Tale.

Aftenposten 1902 nr 635.

Den förnämsta lefnadsregelen.

Aftonbladet 1902 julenr, s 2: Den förnämsta lefnadsregelen. Uttalanden från framstående personer.

1903.

Guld og Sølv, Kobber og Jern. A. Verdens Guldproduktion. B. Verdens Sølvproduktion. C. Verdens Kobberproduktion. D. Verdens Jernproduktion.

Aftenposten 1903 nr 1, 4, 10, 15, 18, 20, 23.

Sverdrup-Expeditionens Samling af Dyreforsteninger.

Aftenposten 1903 nr 49.

Neanderthal-Mennesket og de ældste fossile Menneskeracer. Nogle nyere Undersøgelser.

Aftenposten 1903 nr 253, 256, 262; 294; 584; jfr 291, 578 av fhv Brigadelæge C. Arbo; 637 av Holm.

Neanderthalmennesket og de ældste fossile Menneskeracer. Nogle nyere Undersøgelser. Separataftryk af »Aftenposten.« Kr.a 1903. 19 s.

Über den Hellandit, ein neues Mineral. (Vorläufige Mittheilung).

Nyt magazin for naturvidenskaberne 41 (1903), s 213–221. Utkom ogsa i »Separataftryk« med bibehold av tidsskriftets pag.

Ofotbanens Betydning. Idag og for vor Fremtidsudvikling.

Aftenposten 1903 nr 392, 393.

Über die chemische Zusammensetzung des Xenotim.

Nyt magazin for naturvidenskaberne 42 (1904), s 1—7. Utkom også som »Separataftryk« med omslagstitel Chr.a 1903 og bibehold av tidsskriftets pag.

Tertiærtidens Menneske i Europa. Nyere Undersogelser.

Aftenposten 1903 nr. 640, 650, 652.

Tertiærtidens Menneske i Europa. Nyere Undersøgelser. Separataftryk af »Aftenposten«. Kr.a 1903. 23 s.

Geologien og vore offentlige Arbeider. I. Kristianialeren som Byggegrund. II. Ekebergrandens Glideplan. Geologiens Nytte ved Jernbaneundersøgelser.

Aftenposten 1903 nr 700, 717, 718; jfr 737, 741 av G. Stenberg.

1904.

Geologien og vore offentlige Arbeider.

Aftenposten 1904 nr 12, 15, 18, 67, 69; jfr 1904 nr 59, 66 av G. Stenberg; Teknisk Ugeblad 1904, s 140—142 av C. T. Melby; s 158: Geologien og vore offentlige Arbeider. Et Tilsvar til Hr. Ingenior C. T. Melby. Af. W. C. Brogger.

Om forekomsten af helium- og radiumholdige uranertser.

Pharmacia. Tidsskriftet for kemi og farmaci 1 (1904), s 49–53, 65–70. Utkom også i Separataftryk 10 s.

Videnskaben og det praktiske Liv.

Aftenposten 1904 nr 162, 164.

Videnskaben og det praktiske Liv. Af Prof. Dr. M. [!] C. Brøgger. Særaftryk af »Aftenposten«. 8 s. [Uten særskilt titelbl.]

Et norsk Videnskabsakademi.

Aftenposten 1904 nr 205, 207, 211, 221; jfr 275 av Professor; 292 av En videnskabelig interesseret.

Et norsk Videnskabsakademi. Av Professor Dr. W. C. Brøgger. Separataftryk af »Aftenposten«. Kr.a 1904. 24 s.

Videnskaben og det praktiske Liv. Et norsk Videnskabsakademi. Separataftryk af »Aftenposten«. Kra. 1904. 8 + 24 s.

Norsk Videnskabelighed og Nansenfondet.

Aftenposten 1904 nr 331, 334.

Samsonstiftelsen.
Aftenposten 1904 nr 435.

Kongsberg Sølvverk. En Berigtigelse.
Morgenbladet 1904 nr 518; jfr nr 515 av M. B.

Jordskjælvet den 23de Oktober 1904.
Aftenposten 1904 nr 604.

(Om Strandliniens Niveau under Stenalderen og Broncealderen i det sydlige Norge. Foredrag i Videnskabs-Selskabets Møde 11. Novbr 1904. Intet referat.)
Oversigt over Videnskabs-Selskabets møder i 1904. Chr.a 1905, s 22. Aftenposten 1904 nr 642.

(»Krageröit«. Foredrag i Videnskabs-Selskabets Fællesmøde 2. Decbr 1904.)
Oversigt over Videnskabs-Selskabets møder i 1904. Chr.a 1905, s 30.

Tofteholmene. II. En forsvunden Vulkan.
Aftenposten 1904 nr 740; jfr nr 736: Tofteholmene I. En Erindring. Af Sophus Aars.

1905.

Strandliniens beliggenhed under stenalderen i det sydøstlige Norge. Med tysk resumé, 11 plancher, 2 karter og 9 figurer i texten. Kr.a 1905, VIII + 339 s, pl I—XI, 2 karter. Norges geologiske undersøgelse. Nr 41.

Lad os skilles i Fred! Til Orientering for svenske Venner.
Aftenposten 1905 nr 67.

(Mindeord over Professor J. Hjort i Videnskabs-Selskabets Møde 10. Marts 1905. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1905. Chr.a 1906, s 7.

(Tale ved introduktionen af professor Henrik Schück i Universitetets festsal 27. marts 1905.)
Aftenposten 1905 nr 175.

(Mindeord over Direktør F. O. Guldberg i Videnskabs-Selskabets Møde 26. Mai 1905. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1905. Chr.a 1906, s 17.

(Om en geofysisk Station i Bossekop. I Videnskabs-Selskabets møte 26. mai 1905. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1905. Chr.a 1906, s 18.

Vor Selvstændighed opgiver vi ikke!
Aftenposten 1905 nr 391, 392.

Hvorledes Allehanda kan gjøre en Fjær til fem Høns.
Aftenposten 1905 nr 398; jfr Nya dagligt Allehanda 1905 n:r 166.

Strandlinjens Beliggenhed i Kristianiadalen siden Istiden.
Aftenposten 1905 nr 505, 515, 530, 541.

(Mindeord over Professor, Friherre von Richthofen i Videnskabs-Selskabets Møde 17. Novbr 1905. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1905. Chr.a 1906, s 26.

1906.

Die Mineralien der südnorwegischen Granitpegmatitgänge. I. Niobate, Tantalate, Titanate, und Titanoniobate.
Videnskabs-Selskabets Skrifter. I. Math.-naturv. Klasse 1906. No 6. Udgivet for Fridtjof Nansens fond. Kr.a 1906 4 bl, 162 s, 8 pl.

Om bergarterne i de skafthulløse øxer af sten.
Bilag II til A. W. Brøgger: Studier over Norges stenalder. Videnskabs-Selskabets Skrifter. I. Math.-naturv. Klasse. 1906. No. 2. Chr.a 1906, s 165—175.

Eine Sammlung der wichtigsten Typen der Eruptivgesteine des Kristianiagebietes nach ihren geologischen Verwandtschaftsbeziehungen geordnet.
Nyt magazin for naturvidenskaberne 44 (1906), s 113—144. Utkom også i Separataftryk med bibehold av tidsskriftets pag.

Norges Bergverksdrift og Konsul N. Persson.
Aftenposten 1906 nr 33.

Fosse og Gruber.
Aftenposten 1906 nr 172; jfr. 175 av Alf Sinding-Larsen.

Om Eiendomsretten til Meteorstene.
Aftenposten 1906 nr 187, 190.

(Om Jordskjælvet i San Francisco. Meddelelse i Videnskabs-Selskabets Møde 20. April 1906. Intet referat.)
Oversigt over Videnskabs-Selskabets Møder i 1906. Chr.a 1907, s 10.

(»Akersdalen før og efter Istiden«. Foredrag på Vinderen efter Indbydelse fra Grænden om Holmenkolbanen 5. mai 1906.)
Aftenposten 1906 nr 271.

(Politisk foredrag på Vinderen 14. aug. 1906.)
Aftenposten 1906 nr 466.

(Innlegg i stortingsdebattene 1906/1907.)
Kongeriget Norges 56. ordentlige stortings forhandlinger 1906/1907. D. 7, 8 (jfr registret over talere).

»Samuel Grube og Sophie Hedwig.« Svar til Prof. Helland. [Av] W. C. Brøgger. J. H. L. Vogt.

Aftenposten 1906 nr 643; jfr nr 613, 614, 644 av Amund Helland.

Dovrebanens Betydning for Bergverksdriften.

Aftenposten 1906. nr 718.

(Mindetale over Professor Dr. Samuel Penfield i Videnskabs-Selskabets Fællesmøde 9. Novbr 1906. Intet referat.)

Oversigt over Videnskabs-Selskabets Møder i 1906. Chr.a 1907, s 26.

1907.

Hellandit von Lindvikskollen bei Kragerö, Norwegen. Hierzu 1 Textfigur.

Zeitschrift für Krystallographie und Mineralogie 42 (1907), s 417—439, Taf V.

Vor Bergverksdrift og Konsul Persson.

Aftenposten 1907 nr 27; jfr 35, 36, 44, av konsul N. Persson; nr 45, 50, 64.

Ved Immatrikuleringsfesten Mandag den 2den September 1907. Tale.

Aftenposten 1907 nr 511, 516, 519; jfr 648, 665; jfr nr 646; 650, 666 av sogneprest Tandberg; Bergens Aftenblad 1907 10/9 [av] Akademikus [ɔ: overlærer Jens Greve]; Kristeligt Ugeblad 1907 14/9, 21/9; Verdens Gang 1907 30/10; Morgenbladet 1907 nr 617, 619.

Ved Immatrikuleringsfesten Mandag den 2den September 1907. Tale af Universitetets Rektor, Professor Dr. W. C. Brøgger. Separataftryk af »Aftenposten«. Kr.a 1907. 24 s.

Vort Universitet sammenlignet med fremmede Universiteter. Tale ved Immatrikuleringen den 2den September.

Aftenposten 1907 nr 544.

Indstilling fra komiteen [nedsatt av Kirkedepartementet under 21. sept 1905 for å fremkomme med forslag om valg av tomt for vikingskibene og kunstutstillingsbygningen] dat. 15. okt. 1907.

Trykt i St prp nr 95 for 1909 (D 2), s 5—6. W. C. B. var formann i komiteen fra 8/12 1906.

Andragende fra det Akademiske Kollegium til Kristiania kommune om et aarligt bidrag til Universitetet. 11 s. [Dat. 19. okt. 1907 og undertegnet av: W. C. Brøgger. Lyder Brun. A. Taranger. C. Boeck. Hjalmar Falk. Parafert: Orland.]

[Andragendet blev ikke fremmet i denne form.]

Andragende fra det Akademiske Kollegium til Kristiania kommune om et aarligt bidrag til Universitetets museer og botaniske have. 5 s. [Dat. 9. okt. 1907 og undertegnet: W. C. Brøgger, Lyder Brun, A. Taranger, C. Boeck, Hjalmar Falk. Parafert: Orland.]

1908.

Universitetets nybygninger. Nationalbiblioteket.
Teknisk ugeblad 1908, s 70—72; jfr s 59 av Redaksjonen.

(Svar paa et angreb paa Nansenfondets styre i Bergens Aftenblad 1908 4/6 nr 154.)
Morgenbladet 1908 nr 323.

(Tale ved Studentersamfundets 75-års-fest.)
Morgenbladet 1908 nr 550; jfr. Afholdsbladet 1908 nr 82, 84, 86 av Johan Scharffenberg; nr 84 av W. C. Brøgger.

(Innlegg i stortingsdebattene 1908.)
Kongeriget Norges 57. ordentlige stortings forhandlinger 1908. D. 7, 8 (jfr register over talere).

1909.

Rustvangen grubefeltet. [Av] W. C. Brøgger og Johan H. L. Vogt. [Kr.a 1909.] 11 s 4°.

Geologisk kartblad Moss 1 : 100000. [Utarb. paa grundlag af Norges geografiske opmaalings rektangelkart.] 2. utg. ved W. C. Brøgger med bistand af C. Bugge m. fl. [Utg. af] Norges geologiske undersøkelse. Kr.a 1909.

(Mindetaler over Direktør A. Gaudry og Professor Friedrich Schmidt i Videnskabs-Selskabets Møde 12. Febr 1909. Intet Referat.)
Oversigt over Videnskabs-Selskabets Møder i 1909. Chr.a 1910, s 2.

Beretning om Nansenfondets Virksomhed i Budgetaaret 1. April 1908—31. Marts 1909. Undert.: For Styret: W. C. Brøgger.
Oversigt over Videnskabs-Selskabets Møder i 1909. Chr.a 1910, s 13—17

Ved Immatrikuleringsfesten Torsdag 2den September 1909. Tale.
Aftenposten 1909 nr 498. Optrykt i »Studentene fra 1909«, Oslo 1934, s 18—23.

(Innlegg i diskusjonen efter H. Reuschs foredrag Om Harøhytten, en Boplads fra Stenalderen, i Videnskabs-Selskabets Fællesmøde 8. Okt 1909.)
Oversigt over Videnskabs-Selskabets Møder i 1909. Chr.a 1910, s 36—37.

Tal.
Invigningen af Stockholms högskolas nya bygnad den 6.—7. december 1909. Minneskrift. Stholm 1910, s 75—77; s 73 fg: Tal af professor H. Bäckström till professor W. C. Brögger.

Til det kgl. Kirkedepartementet [fra det Akademiske Kollegium angående »Opførelse af en Fest- og Examenssal for Universitetet«]. [Kr.a] 1909. 8 s. 4°.
Uten særskilt titelblad. Undertegnet: W. C. Brøgger, Lyder Brun, Oskar Jæger, Hagb. Strøm, Olaf Broch; parafert: Orland.

(Innlegg i stortingsdebattene 1909.)
Kongeriget Norges 58. ordentlige stortings forhandlinger 1909. D. 7, 8 (jfr. register over talere).

1910.

Domfældelsen. (I anledning av »Aftenposten«s offentliggjørelse av Videnskabs-Selskabets kjøp av Drammensveien nr 78 før de andre Kristiania-aviser.) Undertegnet: Olaf Broch, W. C. Brøgger, Axel Johannessen. Dat. 14. april 1910.
Morgenbladet 1910 nr 204.

Verdens Universiteter. Lidt Universitetsstatistik.
Aftenposten 1910 nr 372, 377.

Er der Fare for Jernhunger? Verdensproduktionens Stigning.
Aftenposten 1910 nr 437, 439, 441.

(Observation dans discussion sur l'érosion glaciaire.)
Compte rendu de la XI:e session du Congrès geologique international (Stockholm 1910). Fasc. 1. Sth 1912, s 479—80.

(Observation dans discussion sur l'apparition soudaine de la fauna cambrienne.)
Compte rendu de la XI:e session du Congrès geologique international (Stockholm 1910). Fasc. 1, Sth. 1912, s 560.

Svenske Universiteter. Vil Norge faa mere end et Universitet?
Aftenposten 1910 nr 601, 603.

Hensynsløs Udnyttelse af de naturlige Herligheder. The Conservation Movement i De forenede Stater.
Aftenpósten 1910 nr 670, 671, 673.

Hensynsløs Udnyttelse af de naturlige Herligheder.
Aftenposten 1910 nr 694, 697, 708.

(Innlegg i diskusjonen efter Rekstads foredrag: Træk av havets og det rindende vands erosion.)
Norsk geologisk tidsskrift 2 (1913), Nr. 13, s 5.

(Innlegg i diskusjonen efter Andr. M. Hansens foredrag: Litt om istidsforholdende i Asker.)
Norsk geologisk tidsskrift 2 (1913), Nr. 13, s 6.

1911.

Vort Universitet.
Aftenposten 1911 nr 64, 67, 70.

Vort Universitet. Af Professor, Dr. W. C. Brøgger. Særtryk af »Aftenposten«. Kr.a 1911. 15 s.

Vort universitet. Dets midler og dets maal. [Kr.a 1911.] 16 s. Det Mallingske bogtrykkeri.

(Byggekomiteen for Universitetets nye festsals svar til det Akademiske Kollegium i anledning av dr. Andreas Auberts artikel om den nye festsal og H. Sinding-Larsens imøtegåelse herav.)
Dat. 9. febr. 1911 og undertegnet bl. a. av W. C. Brøgger. Kunst og kultur 1 (1910/11), s 267.

Forslag fra det Akademiske Kollegium angaaende byggearbeider for Universitetet. [Dat. 11. febr. 1911.] 4° 21 s. Uten særskilt titelblad. Undertegnet: W. C. Brøgger, Olaf Broch, A. Brandrud, Oskar Jæger, Francis Harbitz; parafert: Chr. Aug. Orland.

(Takk til dr. Gade for hans antropologiske kart over Norge i Videnskaps-Selskapets møte 21. april 1911.)
Oversigt over Videnskaps-Selskapets møter i 1911. Kr.a 1912, s 14.

(Innlegg i diskusjonen efter D. Cappelens foredrag: Om grubedriften i Fehnsfeltet.)
Norsk geologisk tidsskrift 2 (1913), Nr. 13, s 9.

Beretning om Nansenfondets virksomhet i budgetaaret 1ste april 1910—31. mars 1911. Undertegnet: For styrelsen: W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1911. Kr.a 1912, s 17—20.

(Tale ved indvielsesfesten i Videnskaps-selskapets nye hus 15de juni 1911.)
Oversigt over Videnskaps-Selskapets møter i 1911. Kr.a 1912, s 26—31.

Spitsbergenexpeditionen.
Aftenposten 1911 nr 273.

(Taler i anledning av Det kgl. Frederiks Universitets hundreårsjubiléum.)
Det kongelige Frederiks Universitets hundredaarsjubilæum 1911. Festberetning utarb; efter opdrag av det Akademiske Kollegium ved Fredrik B. Wallem. Kr.a 1913. Her er trykt en rekke kortere og lengere taler av Brøgger som Universitetets rektor.

Universitetets Jubilæum og Jubilæumsfondet.
Aftenposten 1911 nr 450, 451.

Ekebergsporveien.
Aftenposten 1911 nr 693.

1912.

(Mindetale over August Michel-Lévy i Videnskaps-Selskapets fællesmøte 9. febr 1912. Intet referat.)
Oversigt over Videnskaps-selskapets møter i 1912. Kr.a 1913, s 6.

Beretning om Nansenfondets virksomhet i budgetaaret 1ste april 1911—31te mars 1912. Undertegnet: For styrelsen: W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1912. Kr.a 1913, s 38—42.

Royal Society's 250-aars jubilæum.
Aftenposten 1912 nr 382.

Program for exkursioner med svenske geologer i Kristianiafeltet 10de til 21de juni 1912. Kr.a [1912]. 10 s, bl.

(Om Kristianiatraktens utviklingshistorie. Foredrag i Norsk geologisk forening 10. juni 1912.)
Norsk geologisk tidsskrift 2 (1913), Nr. 13, s 39.

Om meteoriter og meteoritregnskurer. En sjelden samling erhvervet af Mineralogisk museum.
Aftenposten 1912 nr 595.

(Komitemedlem.)
[Medlem av den av Landbruksdepartementet under 6. juli 1912 nedsatte komite til undersøkelse av spørsmålet om flytning av Landbrukshøiskolen til Kristiania eller nærmeste omegn. Komiteen avgav ingen samlet innstilling.]

Hr. Kanaldirektør Sætren [i anledning av hans angrep på Magistraten fordi den har satt en geolog inn i den komite som har fått i opdrag å undersøke årsaken til sprekkdannelsene i gårdene på strøket Wergelandsveien—Pilestredet o. s. v.]
Morgenbladet 1912 nr 685; jfr nr 696 av G. Sætren.

1913.

(Mindetale over professor R. Collett i Videnskaps-Selskapets møte 31. jan 1913. Intet referat.)
Oversigt over Videnskaps-Selskapets møter i 1913. Kr.a 1914, s 2.

(Innlegg i diskusjonen efter Scheteligs foredrag: Hitteren og Smølen.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 8—10.

(Innlegg i diskusjonen efter Reusch's foredrag: Litt fra en reise til Skottland.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 11.

Beretning om Nansenfondets virksomhet i budgetaaret 1ste april 1912—31te mars 1913. Undertegnet: For styrelsen W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1913. Kr.a 1914, s 43—48.

Ørjan Olsens expedition til Sibirien. Et alvorsord og en appel.
Aftenposten 1913 nr 572.

Porfyr og sandsten i Brumunddalen. Foredrag.
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 14—15; 16: diskusjon.

Forslag til nyt gageregulativ for Universitetets professorer og øvrige embedsmænd fra den av det Akademiske Kollegium den 14de september 1912 nedsatte komite. Kr.a [1913]. 4°. 31 + upg. s.
W. C. Brøgger var komiteens formann. Dens øvrige medlemmer var S. Michelet, N. Rygg, Sophus Torup, Marius Hægstad.

Til Videnskapsselskapets bestyrelse. Betænkning fra den av Selskapet nedsatte komite om bestemmelser for indvalg av nye medlemmer i Selskapet. Undertegnet W. C. Brøgger, Axel Johannessen, A. Kjær, Aksel S. Steen, Alf Torp. Dat. 21/11 1913.
Oversigt over Videnskaps-Selskapets møter i 1913. Kr.a 1914, s 83—86.

(Nyere undersøkelser om Kristianiafeltets vulkanhistorie. Foredrag i Videnskaps-Selskapets fællesmøte 5. decbr. 1913.)
Oversigt over Videnskap-Selskapets møter i 1913. Kr.a 1914, s 81—82.

Norges deltagelse i international vulkanologisk forskning. Foredrag.
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 17—18; 18 : diskusjon.

(Innlegg i diskusjonen efter Werenskiolds foredrag: En tilnærmet metode for beregning av en isbræs tykkelse.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 18—19.

1914.

Norges geologi. Med illustrationer og kartskisser samt et geologisk oversigtskart.
Norge 1814—1914. Redaktionskomité: W. C. Brogger, A. N. Kiær, Moltke Moe, Bredo Morgenstierne, Gerhard Munthe, Fridtjof Nansen, Eilif Petersen,

Nordahl Rolfsen, J. E. Sars, E. Werenskiold. Hovedredaktion: Nordahl Rolfsen og E. Werenskiold. Tekst og billeder av norske forfattere og kunstnere. Øket folkeutgave av nationalverket Norge i det XIX aarhundrede. Bd 2. Kr a 1914, s 196—234.

(Forslag til tillæg i Videnskaps-Selskapets statuter § 10 fremsat i extraordinært fællesmøte 16. jan. 1914.)
Oversigt over Videnskaps-Selskapets møter i 1914. Kr.a 1915, s 1.

(Mindetale over professor H. Rosenbusch i Videnskaps-Selskapets møte 30. jan 1914. Intet referat.)
Oversigt over Videnskaps-Selskapets møter i 1914. Kr.a 1915, s 3.

(Mindetale over professor Rosenbusch. Intet referat.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 65.

(Innlegg i diskusjonen efter Thorolf Vogts foredrag: Kysteruptiverne i Tromsø amt.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 68—70.

(Innlegg i diskusjonen efter Holtedahls foredrag: Et par nye fossilfund paa Søndre Land i øst for Randsfjord.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 71.

Beretning om Nansenfondets virksomhet i budgetaaret 1ste april 1913—31te mars 1914. Undertegnet: For styrelsen W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1914. Kr.a 1915, s 45—51.

Testamenter til videnskaben.
Aftenposten 1914 nr 227; jfr Tidens Tegn 1914 4/5.

(Mindetale over professor Eduard Suess.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 73.

(Innlegg i diskusjonen efter Reusch's foredrag: Bidrag til Hitterens og Smølens geologi.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 74.

(Mindetale over professor Eduard Suess i Videnskaps-Selskapets møte 20. novbr 1914.)
Oversigt over Videnskaps-Selskapets møter i 1914. Kr.a 1915, s 89—91.

(Innlegg i diskusjonen efter Rekstads foredrag: Iagttagelser fra terrasserne i Aardal.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 74—76.

Om Jarlsbergs porfyromraade.
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 77.

(Innlegg i diskusjonen efter Holtedahls foredrag: Om fjeldbygningen ved Randsfjordens nordende.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 77.

(Innlegg i diskusjonen efter Th. Vogts foredrag: Meddelelse om klæberstenen fra Vaage i Gudbrandsdalen.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 78.

(Innlegg i diskusjonen efter Bjørlykkes foredrag: Om undergrundsbanen og aarsaken til sprekkedannelse i husene i Kristiania by.)
Norsk geologisk tidsskrift 3 (1916), Nr. 10, s 79, 83.

1915.

(Innlegg i diskusjonen efter Holtedahls foredrag: Nogle foreløbige meddelelser fra en reise i Alten.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 31, 33.

(Innlegg i diskusjonen efter Reuschs foredrag: Bemerkninger om Littorinasænkningen.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 33.

(Innlegg i diskusjonen efter Kiærs foredrag: Nye undersøkelser over Holmiafaunaen ved Tømten.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 38.

Uttalelse av 27de april 1915 angaaende forskjellige byggesaker og tomtespørsmaal ved Universitetet. Tr. som ms. Kr.a 1915. 2 bl, 29 s 4°.

Beretning om Nansenfondets virksomhet i budgetaaret 1ste april 1914—31te mars 1915. Undertegnet: For styret W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1915. Kr.a 1916, s 25—39.

Nansenfondet har modtaget kun 200 kr. som gave paa 10 aar. En appel af professor Brøgger [i Videnskaps-Selskapets møte 3. mai.]
Aftenposten 1915 nr 220.

Forslag til nye lønsregulativer for Universitetets embeds- og tjenestemænd. Utarbeidet av en komite, nedsat av det Akademiske Kollegium den 17. april 1915. Tr. som ms. Kr.a 1915. 42 s 4°.
W. C. Brøgger var komiteens formann. Dens øvrige medlemmer var: H. Berner, Halvdan Koht, N. Rygg, J. Schetelig.

»Om oprettelse af et frit universitet i Bergen.«
Aftenposten 1915 nr 579, 583, 588, 591. Bergens Tidende 1915 nr 315, 318, 319, 322.

(Innlegg i diskusjonen efter Goldschmidts foredrag: Om høifjeldskvartsen.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 46, 47, 53.

(Innlegg i diskusjonen efter Rekstads foredrag: Om strandlinjer og strandlinjedannelser.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 48.

(Innlegg i diskusjonen efter Reusch's foredrag: Om Vieskaret i Søndfjord.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 48.

(Innlegg i diskusjonen efter Reusch's foredrag: Litt om kulholdig substans fra Hallingdal.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 48.

1916.

Videnskaben og den industrielle krig. Et videnskabsdepartement. Sir William Crookes' Adresse ved Royal Society's aarsmøde.
Aftenposten 1916 nr 46.

Vort lands videnskab trænger større økonomiske ressourcer. En sammenligning med Danmark og Sverige.
Aftenposten 1916 nr 76.

Fridtjof Nansens fond til videnskapens fremme. 1896—1916. Utgit for Fridtjof Nansens fond. Tr. som ms. Kr.a 1916. 3 bl, 103 s 4°. Tr. i 300 eksemplarer.

Bronsecelten fra Bøle nær Porsgrund. En bestemmelse av strandlinjens høide under yngre bronsealder i den sydlige del av Kristianiafeltet.
Oldtiden. Tidsskrift for norsk forhistorie 7 (Kr.a 1918), s 37—63. Utkom også i Særtryk med titel: Bronsecelten fra Bøle nær Porsgrund. 1916. Med bibehold av tidsskriftets pag.

Sulitelma.
[Skrevet 1916 i anledning av Sulitelma aktiebolags 25-aars jubilæum og trykt 1918 med enkelte forandringer.] Tidsskrift for bergvæsen 6 (1918), s 111—114.

(Innlegg i diskusjonen efter Th. Vogts foredrag: Kalkspatførende pegmatitgange paa Seiland.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 267.

Om fundet av en bronceøks ved Porsgrund.
Norsk geologisk tidsskrift 4 (1916, 1917), s 269—270.

Beretning om Nansenfondets virksomhet $^{1}/_{4}$ 1915—$^{31}/_{3}$ 1916. Undertegnet: For styrelsen W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1916. Kr.a 1917, s 63—69.

Uttalelse i tilknytning til Nansenfondets aarsberetning.
Oversigt over Videnskaps-Selskapets møter i 1916. Kr.a 1917, s 18—31.

(Innlegg i diskusjonen efter Øyens foredrag: Om geologisk tidsregning.)
Norsk geologisk tidsskrift 4 (1916, 1917), s 270—271.

Konsul N. Perssons virksomhet i Norge.
Konsul N. Persson. Med anledning af hans 80-årsdag. Helsingborg 1916. 4° S 129—138.

Vort lands videnskab trænger større økonomiske ressourcer. En sammenligning med Danmark og Sverige.
Aftenposten 1916 nr 76. Gjengitt i Bergverksnytt 1917, s 198—199.

(»The National Research Council«, dets grundlæggelse og maal. Foredrag i fællesmøtet 1ste december 1916.)
Oversigt over Videnskaps-Selskapets møter i 1916. Kr.a 1917, s 44—54: diskusjon s 55—56.

»The National Research Council«. En institution for fremme af det videnskabelige forskningsarbeide i statens interesse, i Amerikas forenede stater.
Aftenposten 1916 nr 627.

Statutter for Sulitelmafondet. Undertegnet: W. C. Brøgger, Hans Reusch, Holm Holmsen, W. Werenskiold.
Norsk geologisk tidsskrift 4 (1916, 1917), s 278—280.

1917.

Oseberghaugens historie.
Osebergfundet. Utgit av den norske stat. Under redaktion av A. W. Brøgger, Hj. Falk, Haakon Schetelig. Bd 1. Kr.a 1917, s 165—197 f°.

Kristianiafeltet. Rektangelbladene: Kristiania og Hønefoss samt deler av Fet, Nannestad og Flesberg. Maalestok: 100 000. [Utarb. paa grundlag av Norges geografiske opmaalings rektangelkart] av W. C. Brøgger og Jakob Schetelig. Utg av Norges geologiske undersøkelse Kr.a 1917[—21]. 5 kart + farveforklaring.
Kartene forelå i ms. 1917 og blev trykt i de følgende år.

Forslag om sløifning av særavdelingen »De før 1907 indvalgte skandinaviske medlemmer« i fortegnelsen over den mat.-naturv. klasses medlemmer fremsat i Videnskaps-Selskapets møte 26. jan. og 9. mars 1917.
Oversigt over Videnskaps-Selskapets møter i 1917. Kr.a 1918, s 5, 9—10.

Videnskaben og staten.
Aftenposten 1917 nr 127.

Beretning om Nansenfondet for aaret 1ste april 1916—31te mars 1917. Undertegnet: W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1917. Kr.a 1918, s 38—52.

Sulitelmafondet.
Aftenposten 1917 nr 269.

Sulitelma.
Aftenposten 1917 nr 311.

Om gjenreisningen af det internationale videnskabelige samarbeide efter krigen. Hvad kan de neutrale lande gjøre?
Aftenposten 1917 nr 353, 355.

Videnskabens betydning for staten.
Aftenposten 1917 nr 604. Optrykt i Bergverksnyt 1917, s 198—200, 202—203.

Uttalelse fra komiteen [nedsatt av Kirkedepartementet under 11. desbr. 1917 til á forberede oprettelse av et forsikringsfond] dat. 22. mars 1918.
Trykt i St prp nr 181 for 1919 (D 2 b), s 8—13. W. C. Brøgger var medlem av komiteen.

Om de nye fond til geologisk forskning. Foredrag [intet referat].
Norsk geologisk tidsskrift 5 (1918 og 1919), s 385.

1918.

(Innlegg i diskusjonen i anledning av I. J. Moltke-Hansens foredrag: Nydannelser i kemisk Industri, Staten og det private Initiativ, i Norsk kemisk selskap, gruppe av P. F., 12. febr. 1918.)
Teknisk ukeblad 1918 s 294 f.

Beretning om Nansenfondet for aaret 1ste april 1917—31te mars 1918. Undertegnet: W. C. Brøgger, formand.
Oversigt over Videnskaps-Selskapets møter i 1918. Kr.a 1919, s 36 -52.

Trondhjems domkirkes gjenreisning.

Aftenposten 1918 nr 64, 66, 68, 71; 114; jfr 90, 159, 171, 201 av professor Olaf Nordhagen; 135 av Johan Meyer, nr 180 av arkitekt H. Sinding-Larsen.

Trondhjems domkirkes gjenreisning. Svar til professor Olaf Nordhagen.

Aftenposten 1918 nr 227, 230; 239; jfr nr 63, 90, 91, 97 av Olaf Nordhagen.

Domkirkestriden.

Tidens Tegn 1918 nr 132; jfr 131 av Erik Werenskiold.

(Innlegg i diskusjonen efter Carstens' foredrag: Trondhjemsfeltets geologi.)

Norsk geologisk tidsskrift 5 (1918 og 1919), s 394.

Carlsbergfondet og Nansenfondet.

Aftenposten 1918 nr 352, 353, 354.

Videnskaben under rationering. En overraskende følge af Amerikaoverenskomsten.

Aftenposten 1918 nr 413.

Innstilling fra komiteen [opnevnt av Kirkedepartementet under 16. okt 1918 til å forberede spørsmålet om opførelse av et nytt fysisk institutt ved Universitetet] dat. 6. desbr. 1918.

Trykt i St prp nr 205 for 1919. (D 2 c), s 1—6; jfr Dok nr 1 for 1920 (D 5). W. C. Brøgger var medlem av komiteen.

(En foreløbig meddelelse om Fensfeltet. Foredrag av W. C. Brøgger og V. M. Goldschmidt i Videnskaps-Selskapets fællesmøte 6. decbr.)

Oversigt over Videnskaps-Selskapets møter i 1918. Kr.a 1919, s 29—30.

I. Forslag til ny ordning av Videnskaps-Selskapets gruppeinddeling og medlemsantal. II. Forslag til ny ordning for de av Videnskaps-Selskapet i Kristiania utgivne publikasjoner. [Fra den av Selskapet 4. juni 1918 nedsatte komité. Undertegnet: Anathon Aall, W. C. Brøgger, Hjalmar Falk, D. Isaachsen, Oluf Kolsrud, N. Wille.]

Oversigt over Videnskaps-Selskapets møter i 1918. Kr.a 1919, s 53—65.

Vore kemikeres utdannelse. Tilsvar til Prof. Dr. C. N. Riiber.

Teknisk ukeblad 1918, s 368—369; jfr 334—335, 422—423 av C. N. Riiber.

1919.

»Eocambrium«. »Kjerulfia lata«.

Norsk geologisk tidsskrift 5 (1918 og 1919), s 378—380.

Innstilling fra komiteen [nedsatt av Kirkedepartementet under okt. 1919 til a fremkomme med forslag om anvendelse av de av Stortinget bevilgede 3 mill. kr. til Forskningsfondet] avgitt i febr. 1920.

Trykt i St prp nr 57 for 1920 (D 2 a), s 2—7. W. C. Brøgger var medlem av komiteen.

Om udsigterne for en gjenoptagelse af det internationale videnskabelige samarbeide.

Aftenposten 1919 nr 72, 76, 82, 85; jfr nr 97, 106.

Institutet for kulturforskning.

Aftenposten 1919 nr 116, 120, 121.

Beretning om Nansenfondet og de dermed forbundne fond for aret 1ste april 1918—31te mars 1919. Undertegnet: For styret W. C. Brøgger.

Oversigt over Videnskabs-Selskabets møter i 1919. Kr.a 1920, s 50—71.

1920.

Uttalelse fra komiteen [nedsatt av Landbruksdepartementet under desbr. 1919 til å avgi uttalelse om de av Norges landbrukshøiskole foreslåtte nybygninger] dat. 21. jan. 1920.

Trykt i St prp nr 116 for 1920 (D 2 a), s 2—7. W. C. Brøgger var medlem av komiteen.

Bergartene i Fehnsfeltet. Foredrag i Norsk geologisk forening 13. mars 1920.

Norsk geologisk tidsskrift 6 (1920 og 1921), s 249—250. Bergverksnyt 1920, s 87.

Beretning om Nansenfondet og de dermed forbundne fond for året 1ste april 1919—31te mars 1920. Undertegnet: For styret W. C. Brøgger.

Oversigt over Videnskaps-Selskapets møter i 1920. Kr.a 1921, s 38—53.

(Innlegg i diskusjonen efter Kiær og Scheteligs foredrag: Fra Brumunddalen.)

Norsk geologisk tidsskrift 6 (1920 og 1921), s 255—256.

(Innlegg i diskusjonen efter H. H. Reusch's foredrag: En ny måte for transport av is.)

Norsk geologisk tidsskrift 6 (1920 og 1921), s 256—257.

1921.

Die Eruptivgesteine des Kristianiagebietes. IV. Das Fengebiet in Telemark, Norwegen. Mit einer geologischen Karte von W. C. Brøgger und V. M. Goldschmidt, einer Übersichtskarte samt 30 Tafeln und 46 Figuren im Text.

Videnskaps-Selskapets Skrifter. I. Mathematisk-naturv. Klasse. 1920. No 9. Utgit for Fridtjof Nansens Fond. 1921. XII + 408 s, 2 pl, Tafel I—XXV (+ 15 bl), 2 kart.

Innstilling fra komiteen [nedsatt av Kirkedepartementet under 4. okt. 1920 til å ta under overveielse omorganisasjonen av Norges geologiske undersøkelse] dat. 21. jan. 1921. 18 + 2 s i manuskript i Handelsdepartementets industrikontor.

W. C. Brøgger var komiteens formann.

Mindetale over prof. dr. Joseph Paxon Iddings holdt i den mat.-naturv. klasses møte den 4de mars 1921.

Oversigt over Videnskaps-Selskapets møter i 1921. Kr.a 1922, s 45—50.

Fridtjof Nansens fond og de dermed forbundne fond til videnskapens fremme. 1896—1921. Utgit for Fridtjof Nansens fond i anledning av Nansenfondets femogtyveårs jubileum. (Med 22 plancher.) Kr.a 1921. VIII + 178 s, tab I—XXII. Tr. i 250 eksemplarer.

Idag for 25 aar siden kom Nansen hjem.

Tidens Tegn 1921 nr. 186.

(Innlegg i diskusjonen efter Carstens foredrag: Av Trondhjemsfeltets geologi.)

Norsk geologisk tidsskrift 6 (1920 og 1921), s 281.

1922.

Die Mineralien der südnorwegischen Granitpegmatitgänge. II. Silikate der seltenen Erden (γ-Reihe und Ce-Reihe.) Von W. C. Brøgger, Th. Vogt, J. Schetelig.

Videnskaps-Selskapets Skrifter. 1. Mathematisk-naturv. Klasse. 1922. No. 1. Utgit for Fridtjof Nansens fond. 1922. Bl, IV + 151 + upg s, Tafel I—XV. S 1—16: Hellandit, Brøgger. Von W. C. Brøgger. (Mit Fig 1 und Tafeln I—VI.)

Om »interessen for videnskaben«. Særaftryk af »Aftenposten« [1922].

4 trespaltede sider i folio. Aftenposten 1922 nr 154, 157

(Innlegg i diskusjonen efter Larges foredrag: Om undergrunnen og fundamenteringsforholdene i Kristiania.)
Norsk geologisk tidsskrift 7 (1922—1923), s 78.

Beretning om Nansenfondets og de dermed forbundne fonds virksomhet for året 1ste april 1921—31te mars 1922. Undertegnet: For styret W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1922. Kr.a 1923, s 45—63.

(Komitemedlem.)
(Medlem av den under 8. mai 1922 av Kirkedepartementet nedsatte komite i den hensikt å opnå et organisk samarbeide mellem de videnskapelige forskningsfond. Noe forslag fra komiteen er ikke avgitt.)

(Bemerkninger til et nyt geologisk kartverk over Kristiania omegn. Foredrag i Videnskaps-Selskapets møte 26. mai 1922. Intet referat.)
Oversigt over Videnskaps-Selskapets møter i 1922. Kr.a 1923, s 23.

Uttalelse [dat. 1. juni 1922] fra den av Arbeidsdepartementet den 18. febr. d. å. i anledning av plan for »Undergrundsbanens fremføring til Studenterlunden« nedsatte kommission. 37 s, pl I—II.
W. C. Brøgger var komiteens formann.

Til Regjeringen og Stortinget. [Henstilling fra Norsk geologisk forening om at kullfeltene på Spitsbergen og Bjørnøya må bli bevart for landet. Dat. 4. juli 1922. Undertegnet av W. C. Brøgger sammen med 11 andre.]
Norsk geologisk tidsskrift 7 (1922 og 1923), s 85—86.

Hvorledes Reusch og jeg blev geologer.
Norsk geologisk tidsskrift 7 (1922 og 1923), s 86.

(Redegjørelse for det nystiftede »Kristiania kommunes fond til norsk videnskaps fremme« i Videnskaps-Selskapets møte 8. decbr. 1922.)
Oversigt over Videnskaps-Selskapets møter i 1922. Kr.a 1923, s 33.

1923.

Geologisk oversiktskart over Kristiania-feltet. Målestokk 1 : 250 000. [Utg. av] Norges geologiske undersøkelse. Utarbeidet av W. C. Brøgger og Jakob Schetelig. Kr.a 1923.

(Innlegg i diskusjonen efter Bugges foredrag: Om Ødegårdens apatitgruber.)
Norsk geologisk tidsskrift 7 (1922 og 1923), s 394—396.

Beretning om Nansenfondets og de dermed forbundne fonds virksomhet for året 1ste april 1922—31te mars 1923. Undertegnet: For styret W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1923. Kr.a 1924, s 40—57.

Mindetale over direktør dr. H. H. Reusch holdt i den mat.-naturv. klasses møte den 5te oktober 1923.
Oversigt over Videnskaps-Selskapets møter i 1923. Kr.a 1924, s 79—89.

1924.

(Oversigt over selskapets utvikling i dets første to menneskealdre. Foredrag i Videnskaps-Selskapets møte 3. mai 1924.)
Oversigt over Videnskaps-Selskapets møter i 1924. Oslo 1925, s 16—26.

Beretning om Nansenfondets og de dermed forbundne fonds virksomhet i budgetåret 1. april 1923—31. mars 1924. Undertegnet: For styret: W. C. Brøgger.
Oversigt over Videnskaps-Selskapets møter i 1924. Oslo 1925, s 58—75.

Hvor længe vil jordens metalbeholdning vare?
Teknisk ukeblad 42 (1924), s 221—222; jfr s 165—166: Hvor længe vil jordens metalbeholdning vare? Af Sigurd Astrup.

Den europæiske adresse til Zaren. Optegnelser og indtryk.
Tidens Tegn 1924 nr 143.

1925.

Mindetale over Sir Archibald Geikie holdt i den mat.-naturv. klasses møte den 23. jan. 1925.
Det Norske Videnskaps-Akademi i Oslo. Årbok 1925. Oslo 1926, s 35—43.

Roald Amundsens fond. [En redegjørelse av professor W. C. Brøgger fra komiteen for innsamlingen.]
Tidens Tegn 1925 nr 261.

(Meddelelse om at professor V. M. Goldschmidt har avslått en kallelse til høiskolen i Charlottenburg, i Videnskaps-Akademiets fellesmøte 4. desbr. 1925.)
Det Norske Videnskaps-Akademi i Oslo. Årbok 1925. Oslo 1926, s 28—31.

1926.

Kristianiafeltet. Rektangelkart: Moss, Kongsberg, Tønsberg med Larvik. Målestok 1 : 100 000. Utarb. på grunnlag av Norges geografiske opmålings originalmålinger og rektangelkart av W. C. Brøgger og Jakob Schetelig. [Utg. av] Norges geologiske undersøkelse. Oslo 1926. 3 kart.

Beretning om Nansenfondets og de dermed forbundne fonds virksomhet i budgettåret $^{1}/_{4}$ 1925—$^{31}/_{3}$ 1926. Av W. C. Brøgger.

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NOTISER

TORVLAG OG STEINLAG I MARIN LEIR VED GRORUD STASJON

Oppover Loelvdalen (Alnadalen) ligger langs begge dalsider en leirterrasse hvis høyde ved Grorud er 130 m o. h. Terrassen består hovedsakelig av marin leir, men inneholder også lag av torv og av grovt rullesteinsgrus. Ved flere anledninger er det ved jordboring funnet torv i leiret, som har vært holdt for å tilhøre gamle ras. I 1939 ble imidlertid gravet en skjæring for en vei under jernbanelinjen ved Grorud stasjon, som viste et torvlag med stor horisontal utbredelse, så det her ikke er tale om en utrasing, men om et torvlag in situ. Torvlaget er 6—8 cm tykt og inneholder smekre stammer eller rotgreiner av lauvtre. Mikrofossilene er velvillig undersøkt av assistent Asbjørn Ording som bemerker at pollenet er dårlig oppbevart. Torven inneholder forholdsvis meget furupollen og en del blomsterstøv av bjørk, men ellers er ikke flere tresorters pollen funnet. Sporer av Sphagnum og av karkryptogamer sees. Det synes å være en terrestrisk torv oppstått av en sumpvegetasjon. Den er dekket av et 4 m tykt leirlag av samme finslemmete leir som det underliggende, og i leirets kontakt mot torvlaget ses intet lag av sand eller grus.

Torvlaget ligger meget nær 4 m under skinnegangen ved Grorud stasjon som angis til 127 m o. h., altså på høyden 123 m o. h. Fra denne høyde er sønnafjells ikke tidligere kjent noen oscillasjon av strandlinjen med terrestriske lag mellom marine. Det overliggende tykke leirlag tyder på en rett betydelig landsenking etter torvlagets avsetting. — I leiret kunne ikke finnes skjell, hverken over eller under torven.

I samme veiskjæring ble også overskåret et steinlag av noen desimeters tykkelse med blokker så store som et mannshode eller større. Mellom steinene ligger grus og sand.

Et lignende lag med stein og grus ble påtruffet sommeren 1937 ved en grunnundersøkelse på leirterrassen ved Sannerud ca. 700 m nordøst for Grorud stasjon. Steinlaget ligger også her helt dekket av leir. Gruset er så tett spekket med store steiner at det ikke er mulig å bore gjennom det med sonderingsbor eller spylebor. Et sted ble det derfor gravet en grøft for å bestemme dets tykkelse. Det var her vel 2.5 m tykt, fast pakket og med blokker så store at de måtte mineres i stykker før de kunne løftes opp av grøfta. Leirtykkelsen over steinlaget er fra et par meter til henimot 13 m. Langs kanten av steinlaget, hvor jordboring kunne drives, viser leirterrassens mektighet under steinlaget seg fra 30 til 50 m. Steinlaget har en meget stor utbredelse. Det strekker seg som et 100 m bredt belte i rettning sydvest-nordøst tvers over den undersøkte eiendom i vel 200 m's lengde og fortsetter til begge sider inn på de tilgrensende områder uten at dets begrensning her er kjent. Dets overflate faller mot nordøst fra 130 m o. h. til 121 m o. h.

Disse steinlag ligger altså sammen med torvlaget innleiret i Grorudterrassen. Vi kan her og der langs strandkanten av våre innsjøer, eksempelvis i Mjøsens sydvestre strand i Feiring se lignende steinlag over leir. Også langs fjordene våre kan en ofte se et steinlag i fjæra selv om stranda består av steinfritt leir. Det er sannsynlig at sånne steinlag deponeres av drivis, og for steinlagenes vedkommende ved Grorud kan kanskje også tenkes at strandete isfjell lastet med morenemateriale kan ha spilt en rolle. Men det forholdsvis tynne steinlag utbredt over et så stort areal synes heller å måtte skrive seg fra en strandavsetting fra drivis enn fra store kalviser med bregrus.

Leirlaget så vel over torven som over steinlagene ved Grorud viser således at landets hevning har vært avbrutt av en betydelig senking, da strandlinjen stod ved 123—130 m over den nuværende.

P. A. ØYEN har i en av sine avhandlinger: Profil i jernbaneskjæring øst for Grorud stasjon, Arch. f. Mathem. og Naturv. B. XXVII, 1906 meddelt lagfølgen på en lokalitet mellom Sannerud og Høybråten, litt østenfor de her omtalte. Da skjæringen for jernbanens dobbeltspor ble utført la han merke til en utpreget diskordans mellom to slags leir, et underliggende rikt mytilusførende og et overliggende sandholdig leir, så skarpt avgrenset fra mytilusleiret at han mente det overliggende måtte være rendt ut over det andre som en leirsuppe. Men da det ikke er noe i landskapsformen som tyder på utglidning tenkte han også på, om det ikke kunne ha vært en oscillasjon i jordskorpens hevning som er skyld i diskordansen.

Grorudterrassen tilhører Øyens pholasnivå. I sin avhandling „Kvartærstudier i Trondhjemsfeltet III“ s. 325, De kgl. Videnskabers selskaps Skrifter 1914 omtaler Øyen et profil som ble ham meddelt av agronom Sigurd Røstad. Ved Hallan, nær Rinnan stasjon mellom Levanger og Verdal ligger en myr i høyden 111 m o. h., som mellom lag med terrestrisk torv inneholder et skjellførende lag av marin opprinnelse. Øyen har ikke selv sett profilet, men der er ingen grunn til å tvile på at de skjell av cardium, mytilus og littorina som han mottok til bestemmelse fra agronom Røstad virkelig skriver seg fra en landsenkning i pholastid, som således tidligere er konstatert for Trondhjemsfeltets vedkommende.

Marine avsetninger over torvlag fra postglacial tid av senere datum har lenge vært kjent av geologene. Rundt hele vår kyst fra Lillesand til Andøya kan vi finne torv eller ferkvannsgytje dekket av svære strandvoller. Torvlaget ligger i liten høyde over havet, som oftest mellom 3 og 10 m, ja på Lista endog under havets overflate på 3—4 m's dyp. — Siden J. HOLMBOE i 1901 ga en foreløpig meddelelse i Nytt Mag. f. Naturv. om en postglacial senking han hadde funnet sporene av i kanalen fra Skeievatn, har senkingen vært ansett for å være samtidig med den

	Torvlaget m o. h.	Strandvollen m o. h.
Dybvigtjern, Lillesand	10,0	15,2
Tjørv, Lista	fra ÷ 5,0 til + 3,5	5,5
Randeberg, Jæren	4,0	5,2
Horr, Jæren	5,0	8,4
Skeie, Jæren	2,0	8,5
Håland, Kvitingsøy	3,0	4,0
Haugevåg, Karmøy	3,0	5,0
Hagevik, Os	3,2	opptil 8,3
Rørvik, Vigra	8,0	9,6
Østnes, Haramsøy	4,5	5,0
Drynesund, Mien	9,9	13,5
Otterlei, Fjertoft	7,3	
Ramså, Andøy	2,5	9,0

baltiske littorinasenking om den enn her til lands har gått under navn av tapessenkingen. Torvlagets høyde over havet og høyden av den strandavsetting som dekker det, fremgår av ovenstående sammenstilling.

Alle disse steder ligger ut mot havet, i all fall ligger de i den ytterste kystsone. Innover fjordene og inne i det tidligere submarine terreng er det ikke iakttatt denne slags spor med strandgrus over torvlag fra tapessenkingen. Vi finner derimot i øygaren ofte utpregete *erosjonsstrandlinjer* i en noe større høyde enn den hvortil de såkalte tapesstrandvoller når opp. Tapessenkingens nivå utmerker seg således fram for andre nivåers strandlinjer ved en morfologisk eiendommelighet, ytterst i kystranden ved de særlig store strandvoller og i øygaren og fjordenes yttre del ved en ganske utpreget strandlinjeerosjon i en høyde noe større enn strandvollenes, inntil 25 m o. h. eller der omkring. Når vi kommer innover fjordene, finner vi den marine grense i høyere nivå jo lenger vi fjerner oss fra kystranden. Desto høyere må følgelig også tapeslinjen søkes. Men hvor den marine grense ligger så høyt som henimot 100 m eller høyere, kan vi ikke mere se den erosjonsstrandlinje som viser seg nærmere kystranden.

Denne omstendighet finner en naturlig forklaring hvis vi antar at tapessenkingen skyldes en stiging av havets nivå. Ute ved kystranden, hvor landhevingen har vært liten, har det blitt en oversvømmelse av landet, litt lenger inne har landhevingen og havstandens stiging holdt skritt med hverandre, men innerst i fjordene hvor landhevingen har vært størst, har den foregått såpass raskt at den ikke har vært innhentet av det stigende havnivå.

Under denne forutsetning blir tapessenkingen synkron for hele landet og torvlagene skulle være omtrent jevngamle.

I de senere år er det imidlertid også inne i landet i marin leir funnet littoralavsettinger og terrestriske torvlag som dels er eldre, dels yngre enn tapestiden. P. A. ØYEN kom ved sine studier av fossilinnholdet i våre marine avsettninger til det resultat at det måtte ha inntruffet en rekke oscillasjoner under landhevingen, en for hvert av de nivåer han oppstiller. Til en lignende anskuelse kom også V. TANNER gjennom sine strandlinjestudier, og de funn som er gjort i senere tid i vidt forskjellige nivåer taler også mere for oscillasjoner i landhevningen enn for antakelsen av like så mange store variasjoner i havnivået.

Sporene av en i Oslotrakten merkbar oscillasjon er i all fall funnet omkring 90 m's nivået. O. HOLTEDAHL beretter om at disse kunne iakttas da gravingen for fundamentene under Det meteorologiske Institutts nye bygning på Blindern ble utført. Det ble da funnet et decimeters tykt sandlag som noen steder ligger direkte på berggrunnen, andre steder over et steinførende leir, men over alt dekket av et tykt lag steinfritt leir. Sandlaget helder utover fra den gamle strand og inneholder rekved av eik, furu og selje samt sneglehus av den alminnelige strandsnegl. Det overliggende leirlag er fra 4,5 til 10 m tykt. — Foran Grefsenmorenen er det mellom Hans Hauges gate og Brettevilles gate funnet et lag av fast grus innleiret på ca. 10 m's dyp i leiravsettingen. Markens høyde er her 90 m o. h. Gruslaget er sannsynligvis utvasket fra Grefsenmorenen av bølgeslaget og senere begravet av leir under den samme transgresjon av havet som den hvis spor kom til syne under gravingsarbeidene på Blindern.

En tredje oscillasjon, når tapessenkingen ikke regnes med, er beskrevet av J. REKSTAD i en avhandling „Et profil fra de løse masser ved Fredrikshald“, Norsk geologisk tidsskrift 1, 1907. Under kanalisering av Tista ble det ved Porsnes like ved Halden i ca. 20 m's høyde over havet foretatt dypgravinger gjennom en leiravsetning som inneholdt et torvlag av betydelig utstrekning. Det viste en tykkelse av 30—40 cm og var dekket av fin sand med et par meters mektighet. Torven inneholdt rester av sumpplanter, og i sandlaget fantes rustfargete sandrør etter annelider, mest sannsynlig etter *Arenicola marina*. Torvlaget ligger ca. 18 m o. h. Oppover Tistedalen er et utpreget terrassenivå i 20—24 m's høyde, så Rekstad mener at den senking hvorved torvlaget ble oversvømmet må ha beløpet seg til 7 à 8 m's høyde.

Foruten tapestidens torvlag under strandvoller kjenner vi således nu også 3 andre nivåer, hvor de marine avsettninger har vært avbrutt av landfacies, nemlig i pholasnivået, mactranivået og i ostreanivået.

Gunnar Holmsen.

GREFSENMORENENS OPBYGNING OG FOSSILINNHOLD

Grefsenmorenen er en klassisk lokalitet for vår norske kvartærforskning, og byr Oslogeologene den ypperste anledning til å studere en submarint opbygget fremstøtsmorene. Her var det (ved A, fig. 1) at P. A. Øyen i sin tid fant de første fossiler i gruset og bestemte den marine grense til 216—217 m o. h.[1] I grustakene har man stadig kunnet

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[1] W. C. Brøgger: Om senglaciale og postglaciale nivåforandringer i Kristianiafeltet (Norges Geologiske Undersøkelse, nr. 31, Kria. 1900—01), s. 211 ff.

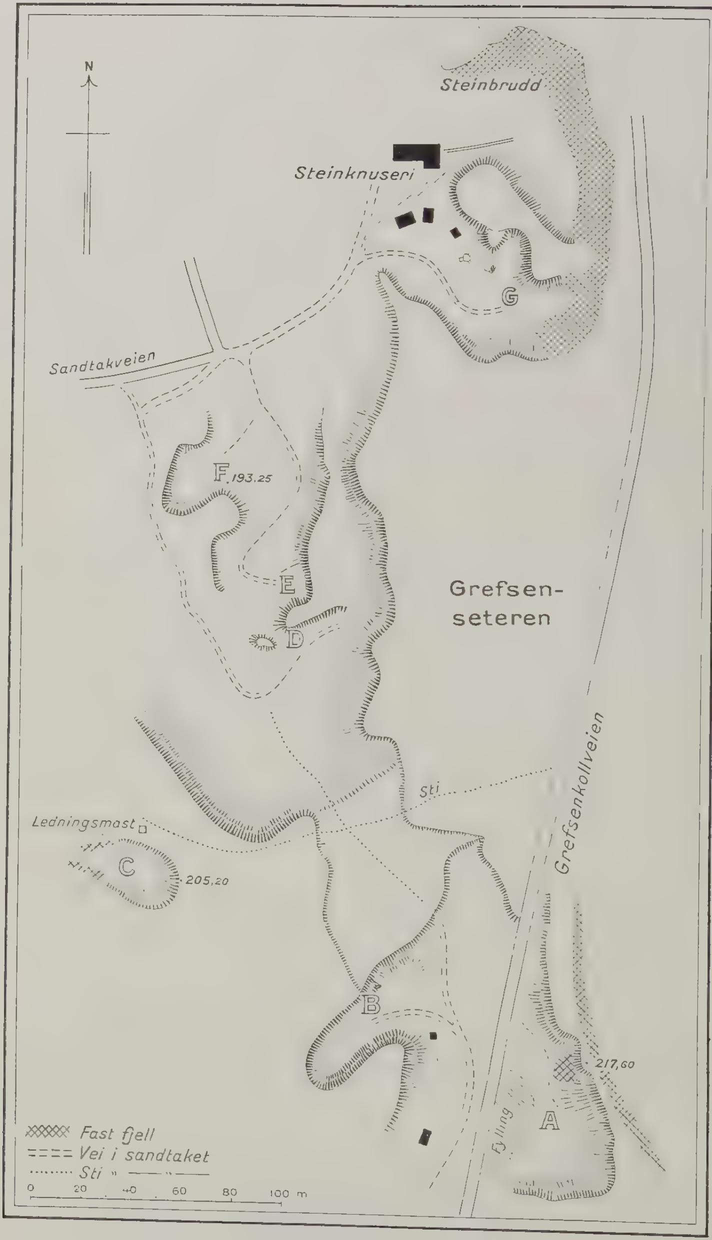

Fig. 1. Sandtakene ved Grefsenkollveien. Målebordskisse optatt 28. oktober 1939. Målestokk 1 : 3000.

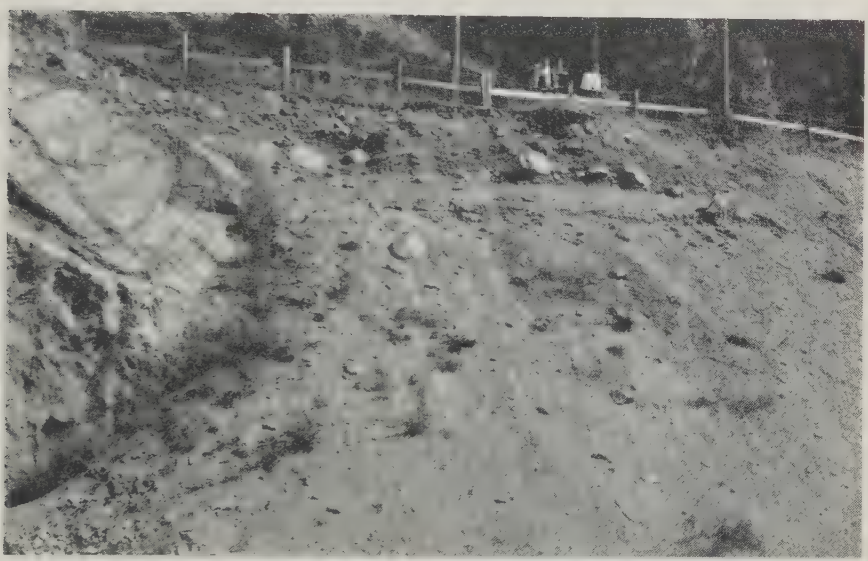

Fig. 2. Det klassiske profil ved A: Ca. $^1/_2$ m horisontalskiktet finsand under den grove skyllesonen på toppen. Nær hornfelsberget t. v. sees at topplaget er nedleiret med diskordans i finsanden, noe lignende t. h. for de store blokkene.
Øverst terrassen 217,60 m o. h., som gjerdet står på.
F. I. fot. $^{21}/_8$ 1938.

se nye snitt. For så vidt har sandgravingen vært en stor fordel, videnskapelig sett; men ulempen er at betydningsfulle profiler efter hvert ødelegges. Det som én forsker har uttalt sin mening om, kan den næste ikke lenger ved selvsyn danne sig en opfatning av.

Gjennem en del år har undertegnede nokså regelmessig fulgt med i utgravingen av Grefsenmorenen, bl. a. ved å ta de studerende med på ekskursjon til dette instruktive sted. For å skaffe et objektivt materiale av iakttagelser som også kan komme til nytte ved fremtidige diskusjoner, har jeg funnet det hensiktsmessig å ta op en målebordskisse (fig. 1) av grustakene langs Grefsenkollveien, for å kunne angi nøiaktig hvor de forskjellige iakttagelser er gjort. Skissen blev optatt og høidene nivellert høsten 1939, med velvillig assistanse av fil. mag. Olof Ängeby og stud. philol. Helge A. Sundt. Dessuten har jeg tatt fotografier av viktigere snitt (fig. 2—6).

Grefsenmorenen strekker sig fra foten av Grefsenkollen og vestover til Akerselvens gjennemskjæring i Nydalen. Den er dannet ved et fremstøt av Maridalsbreen, som derved rotet op igjen leire og sand som tidligere var avsatt på innsiden (nordsiden) av den nuværende moreneryggen. Breen gikk under fremstøtet fremdeles ut i en fjordarm. Ved brefronten blev det fremskjøvne materiale avleiret på ny, sammen med grus og sand fra breelvene. I hvert fall innunder Grefsenkollen blev morenen bygget op til havoverflaten. En klar og tydelig terrasse med høide 217,60 m o. h.[1] avslutter her løsmassene inn mot åssiden (ved A, fig. 1).

Resten av den svakt hvelvede moreneryggen videre vestover ligger under den marine grense og stort sett i en høide av ca. 180 m o. h., ifølge kartene. Morenen er dukket frem av havet efter hvert som landet hevet sig. Bølgeslaget har tæret på løsmassene, finmaterialet er skyllet vekk, mens blokkgruset er blitt liggende igjen. Dette overflatelaget med „anrikning“ av blokker kan være ½—2 m tykt og er en utvaskningssone eller skyllesone. Hvor høit morenen oprinnelig var bygget op, og om den f. eks. nådde op til havnivået da breen var rykket frem hit, kan vi ikke si noe sikkert om. Det rimeligste er kanskje at den ikke var bygget så høit op, da det enkelte steder, således på platået litt nord for stoppestedet Glads vei, finnes leire i overflaten, avsatt oppå morenen da den ennu lå under vann.

Grefsenmorenens nuværende form er altså sekundær. Den fremtrer nok ennu som en skuvrande, en rygg som skiller mellem Oslodalen og forsenkningen nordover mot Maridalsvatnet. Men den er nedslitt og utjevnet av bølgeslaget under hevingen, og den er som nevnt også noe tiljevnet ved avsetning av leire i flekker på overflaten.

Når en slik rygg dukker op i havflaten, kan svære masser flyttes og omleires hvis brenningen tærer på sand. Er materialet uensartet, vil blokkene og det grove grus ligge igjen og danne et skall som verner mot videre nedrivning. Tettpakkede, harde leiremasser vil også stå bedre imot abrasjonen enn sand. På Grefsenmorenen er det meget almindelig at skyllesonen hviler direkte på et kompakt, leireholdig materiale. Denne leiremassen viser ikke skiktning, men inneholder rester av havskjell, for det meste opknuste småbiter, men også noen hele. Leiren er altså sikkert nok oprinnelig en havavsetning, om den enn ikke fremtrer slik nu lenger. Tolkningen av denne fossilførende leiremassen er avgjørende for ens opfatning av Grefsenmorenens indre bygning.

I snittet ved A (fig. 2) ligger underst et mektig rullesteinsgrus med skråttstilte lag som faller distalt sydover. Over det følger ½ m vel sortert, fin sand i horisontale lag, og så øverst 1—2 m grovt blokkgrus, tiljevnet oventil som en terrasse 217,60 m o. h. inn mot det opstigende, nakne hornfelsberget.

Uheldigvis kan man ikke nu lenger se noe snitt i den forekomst hvor P. A. Øyen fant *Saxicava arctica*, *Mytilus edulis* og *Balanus crenatus*. Det er dog helt på det rene at funnet blev gjort i sandgropen ved A, på østsiden av veien. „Fossilerne fremgravedes“, skriver Øyen[2], „af en linse lerblandet grus. Denne linse viste i snitt en mægtighed af omtrent tre decimeter og en længde af henimod fem meter. Den lå i skrå stilling, der fuldstændig svarede til den tydelige strandskiktning på stedet, og i en dybde af fire til fem meter under overfladen.“ Denne siste oplysning gjør Øyens tolkning av linsen som et strandgrus in situ meget tvilsom. Sandtaket er nu drevet inn til fjellsiden; men skyllesonen kan ikke ha vært tykkere enn den vi nu ser, lenger ut ifra strandkanten — heller tvert om. „Fire til fem meter under overfladen“ fører da ned i skråskiktede masser av breelvgrus. Da sandtaket ennu var i drift, fant arbeiderne her klumper av den opprotede leiren liggende som „rullestein“ i dette gruset. En mulig parallell til Øyens skråttstilte, lerblandede gruslinse vil bli omtalt nedenfor s. 260

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[1] Nivellert to ganger fra Aker Opmålingsvesens fastmerke i ledningsmast ved Kjelsåsveiens brannstasjon bolt 311 = 189,11 m o. h.

[2] W. C. Brøgger: Nivåforandringer etc., s. 211—213.

I finsandlaget næst øverst ligger de underste 10 cm og de øverste 15 cm noenlunde horisontalt, mens resten av sandlagene viser nedbøininger med gryteformet eller traugformet tverrsnitt (fig. 3). Denne struktur tolkes vanligvis som merker efter undersjøiske glidninger i en sedimentmasse. Det har for øvrig ikke vært reist noen tvil om at finsandlaget er avsatt under vann.

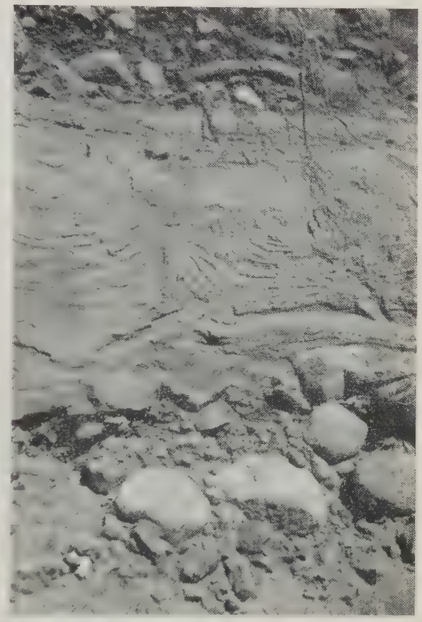

Fig. 3. Detalj av finsandlaget kloss nord for det avdekkede hornfelsberg ved A. Det øverste og underste av finsanden ligger horisontalt, lagene imellem viser traugformige nedbøininger. Under finsandlaget sees noe skarpkantet hornfels iblandet. F. I. fot. 21/8 1938.

Blokkgruset på toppen er bearbeidet av sjøen og fremtrer nu som en skyllesone, men må jo også oprinnelig ha hatt en helt annen sammensetning enn finsanden. Det kreves sterkere krefter for å føre frem en slik blokkmasse. W. C. Brøgger mente det var unødvendig å tenke sig en fremrykning av breranden som årsak til blokkene i topplaget; „de må være udskyllede fra brægrus efterladt på dalsiderne og have rullet i stranden ved nordsiden af det svære åbne fjordgab, som må have udbredt sig ved foden af Nordmarkens høidedrag i baggrunden af dalen på denne tid.“[1] Holtedahl vil derimot tolke løsmaterialet helt til tops som „glacifluviale eller glacimarine dannelser“.[2]

Topplaget består av rundede blokker og inneholder så godt som intet hornfelsmateriale fra fjellsiden ovenfor, men bare fjerntransporterte rullestein og blokker, overveiende syenitter. Et sted såes at topplaget har leiret sig ned i finsanden som en flat skål, så at finsandlagene avskjæres og en diskordans opstår, som tegn på at blokkmassene er ført frem med makt. I krattet straks sønnenfor finnes blokkgruset igjen op til 3—4 m høiere[1] enn MG-terrassen, også her i utvasket tilstand, ikke med karakter av bunnmorene. Det må være avleiret i umiddelbar tilknytning til en brerand. Om det er skjøvet hit av isen eller transportert av en breelv, er i grunnen et mindre vesentlig spørsmål. Likesom Holtedahl skulde jeg nærmest anta det siste, da en skyvemorene her inne ved fjellfoten sannsynligvis vilde ha kunnet opvise mere hornfelsmateriale.

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[1] W. C. Brøgger; Nivåforandringer etc., s. 217.

[2] Olaf Holtedahl: Studier over isrand-terrassene syd for de store østlandske sjøer (Vid. selsk. skrifter, Mat. -naturv. klasse 1924, nr. 14, Kria. 1924), s. 80

Har topplaget oprinnelig vært breelvgrus, må det fra først av ha vært avsatt op til den samme høide hvori vi nu finner det samme grus i krattet sønnenfor, altså 3—4 m høiere enn terrassen 217.60 m, da en gruskjegle skal ha fall ut fra brekanten. Like op for terrassen stiger imidlertid berget bratt op. Her har brenningen klart å vaske alt breelvgruset ned til strandnivået, og hornfelsberget står nakent igjen. Like sønnenfor skjærer derimot et lite dalsøkk inn i sydøstlig retning. Blokkgruset har her ligget litt mindre utsatt og ikke på så bratt hellende underlag.

Spørsmålet er nu: Representerer dette grove rullesteinsgruset på toppen et nytt fremstøt efter at brefronten under avsetningen av finsanden nærmest under hadde stått lenger borte? I så fall skulde det underste breelvgrus være avsatt under en eldre oscillasjon, topplaget under en yngre, og disse to fremstøt skulde være adskilt ved en roligere periode med avsetning av finsedimenter.

Denne mulighet som allerede W. C. Brøgger hadde overveiet, har særlig vært understreket i foredrag og på ekskursjoner av cand. real. Erling Jahr, i forbindelse med strandlinjestudier fra hele Oslodalen. Forhåpentlig vil resultatene av hans omfattende målinger snart kunne foreligge, så spørsmålet kan diskuteres i en videre sammenheng. Når jeg for min del er kommet til å avvise en slik tvedeling i Grefsenmorenen, så skyldes det grunner som vil fremgå efter hvert nedenfor av forholdene i morenens øvrige snitt. Det skal innrømmes at man kunde være i tvil, hvis man bare hadde tilgang til det ene klassiske profil ved A.

Ved B hviler skyllesonen direkte på leire, som imidlertid ikke danner noen stratigrafisk motsvarighet til finsandlaget ved A. Leiren gir i det hele inntrykk av å befinne sig i sekundært leie. Den viser raskt skiftende mektighet og ingen klar lagdeling lenger, den er rik på grus og småstein og inneholder rester av opknuste skjell, men også noen få hele eksemplarer (*Mytilus edulis*, *Macoma calcarea*, *Saxicava arctica*, *Balanus)*. Leirelaget eller „-pakken“ ligger bøiet og skjæres over med diskordans av skyllesonen, som her er ca. ½ m mektig. Innerst i kroken går det en „arm“ av leiremassen på skrå ned i underliggende grus i distal (sydlig) retning. Dette minner om de innpressede kiler eller flak som kan iakttas nær skyveplanet, hvor en kompakt bergmasse har vært skubbet hen over en mere eftergivende.[2]

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[1] Efter måling av cand. real. Erling Jahr.

[2] Sml. f. eks. de kiler av sandsten i kambrisk skifer som er beskrevet i Trygve Strand: Nordre Etnedal. Beskrivelse til det geologiske gradteigskart (Norges Geologiske Undersøkelse, nr. 152, Oslo 1938), s. 30. ff.

Dette var hvad man kunde slutte sig til av de snitt som var tilgjengelige for studium i 1939. Våren 1940 var det gravd et stykke videre rett mot syd fra innerenden av sandgropen ved B, og det blev da avdekket et profil som sterkt støtter opfatningen ovenfor. Dels finner man i det nye profil likesom ved B en uordnet, omrotet leiremasse av morenelignende utseende like under skyllesonen, men dels såes også like under den blokkrike skyllesonen men over moreneleiren et sandlag med horisontale skikt, svarende til finsandlaget ved A. En og annen stein med 10—20 cm diameter fantes i denne sanden. I den underliggende massen av rullesteinsgrus og leirerik morene fantes også en klump som inneholdt skjellfragmenter.

Som nevnt finnes nokså almindelig leiren like under skyllesonen, idet utvaskningen er stanset på det kompakte materialet. Like nord for B er således et felt hvor man ved sandgravingen bare har skrellet av skyllesonen, som ligger oppå ubrukelig leire. Dette trekk ved morenens bygning, som i virkeligheten bare er sekundært, kan lett skape falske forestillinger om en oprinnelig regelmessighet.

Ved C ligger løsmassene på fast fjell, en nordmarkittisk grense- eller gangbergart. På en studenterekskursjon for noen år siden under ledelse av professor W. Werenskiold fantes her *Mytilus edulis* i leirerike partier i morenen. Like over berget lå det noe bedre sortert sand.

Ved D stakk det i 1939—40 op to store klumper som sandtekten omhyggelig hadde gått utenom. Efter konsistensen kunde de bare betegnes som moreneleire, med grus og småstein, og blågrå av farve. Da dette ligger nær det dypeste i grustaket, var det rimelig å anta at man her stod overfor selve kjernen i morenen, en fremskjøven, fastere masse som efter hvert var begravet i rullesteinsgruset. Ved nærmere eftersyn fantes små skjellsmuler også i denne morene, og da sandgravingen høsten 1939 nærmet sig klumpene nordfra, viste det sig ved E at moreneleiren også her er flyttet frem og avsatt igjen oppå sand. Ved E var det blottet 3 m sand med tilnærmet horisontal lagdeling under moreneklumpen. I sanden såes en enkelt større, ikke rundet stein. I vestveggen av denne gropen var sandlagene bøiet ned og viste fall mot nord — langs overkanten av disse nedbøide lagene er moreneleiren skjøvet frem. Forstyrrelser i form av ombøininger og småkrøller såes i de øverste lag av sanden, og ned gjennem sandmassen skar det steiltstående sprekker i flere retninger. Langs disse var lagene forkastet noen cm.

Den rikeste fossilforekomst i morenen blev funnet i mars 1938 ved F. Her lå det en klump sandblandet leire som av en eller annen grunn var blitt mindre omknadd under transporten. Skjellene forekom derfor i stor utstrekning hele, og ikke sjelden med sammenklappede valvler. Følgende arter er påvist:

Macoma calcarea (mest av denne)
Mytilus edulis (små skjell)
Saxicava arctica
Axinus flexuosus
Cyprina islandica

Lepeta coeca (1 eksemplar)
Mya truncata (knuste skjell)
Balanus porcatus og *B. crenatus*
Cylichna sp.
Natica sp.

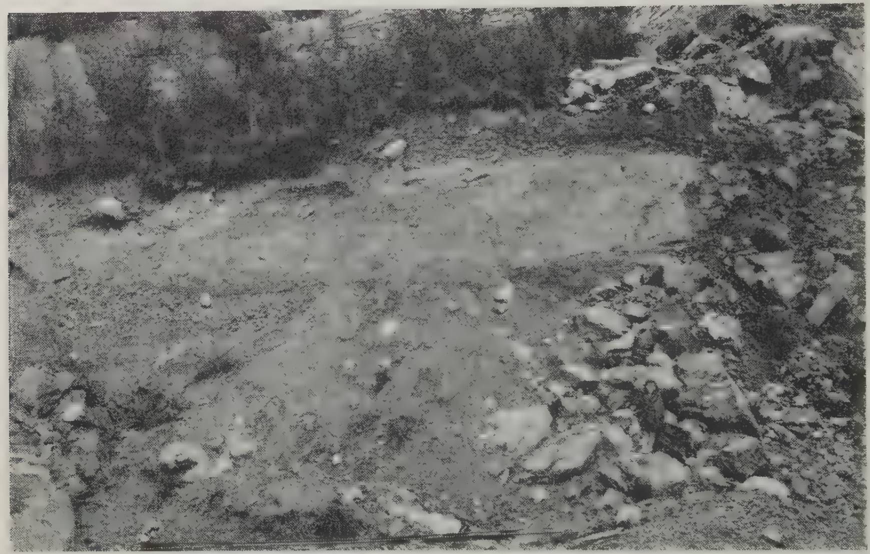

Fig. 4. Halvt linseformet leireflak ved G. Det støter med tykkenden inn mot fast fjell t. h. Merk stein og blokker i den ikke lagdelte leiremassen.
F. I. fot. 21/8 1938.

Dette er samtidig en opregning av hele Grefsenmorenens fossilinnhold, da det ikke noensteds i morenen er funnet andre skjell enn dem som inngår i denne listen. *Mya truncata* fantes i en brun leirefattig sand som omgav leireklumpen på den ene siden.

For hjelp med bestemmelsen av fossilene takker jeg professor dr. Hjalmar Broch, statsgeolog dr. Gunnar Holmsen og konservator Halvor Rosendahl.

Ca. 30 m rett syd for F var det i august 1938 blottet regelmessig lagdelt sand med fall mot S—SSE. Enkelte av sandlagene inneholdt smått skjellsmulder, og i et leireblandet lag fantes til dels også hele skjell av *Macoma* og *Mytilus*. Alt dette er utvasket fra partier av den oprotede, fossilrike leiren og avsatt igjen foran breranden i sandmasser som er skyllet frem av breelvene. Denne forekomst har stor interesse for opfatningen av Øyens fossilførende „linse lerblandet grus" ved A.

Ved G ligger en halvt linseformet masse av kompakt, steinførende og ikke lagdelt leire som støtter sig til fjellsiden med tykkenden (fig. 4) — altså ikke utkilende inn mot hornfelsberget som her stiger bratt op. I leiren finnes skjellfragmenter, som en sjeldenhet også *Saxicava arctica* med begge skall sammenklappet, uten at dette danner noe bevis for at leiren ligger i oprinnelig leie.[1]

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[1] Sml. Thorolf Vogt: Brevariasjoner ved Raudefjorden (Redbay) på Spitsbergen (Norsk geol. tidsskr., bd. 9, Oslo 1927), s. 308.

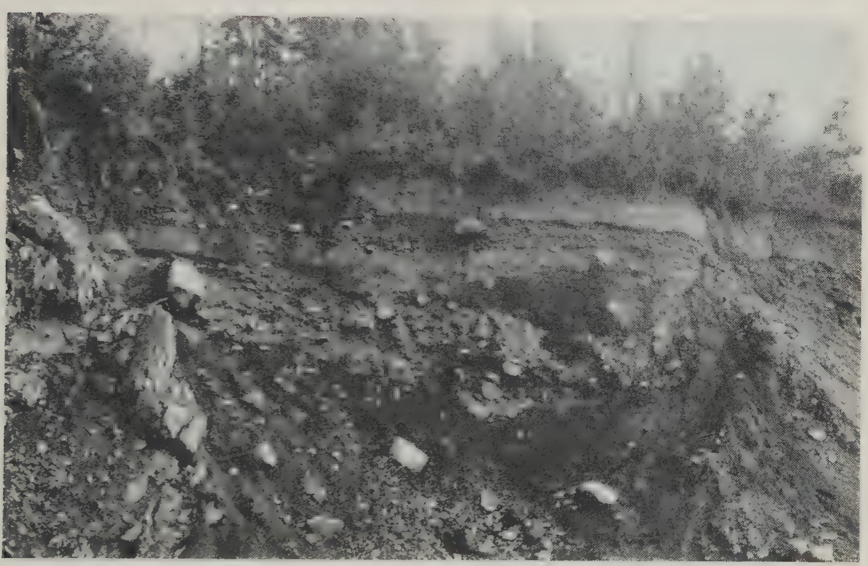

Fig. 5. Sydveggen av grusgropen ved G. Fra fast fjell t. v. kan man følge et leirelag utover til høire Over dette, og adskilt ved et grovt gruslag, sees et annet leirelag som er butt avkuttet nær en stor stein. Dette er en typisk skyveflaktektonikk. F. I. fot. 21/8 1938.

Den motsatte side av gropen ved G viser „lag" eller „pakker" av moreneleire flakvis oppå hverandre (fig. 5) og med blokkrikt grus innimellem — en typisk „Glazialschollentektonik", efter tysk ordbruk.

I venstre halvdel av fig. 4 sees under leirelaget uskiktet, skarpkantet hornfelsmateriale, som i sin tur hviler på en sone med skiktet grus. Dette grusskiktet kommer igjen øverst på fig. 6, som er tatt noen få meter nord for G. Underst ligger her en merkelig masse av skarpkantet hornfels fra fjellsiden ovenfor, av størrelse varierende fra kolossalblokker til smuler, blandet med vel rundede, fjerntransporterte syenittrullestein. Dette må være et steinras fra tiden før grusskiktet blev avsatt og før leireflakene blev skjøvet frem. Men breranden må ha stått i nærheten, så rasmassen har kunnet blande sig med rullestein fra breelvene. Det er dette gamle steinraset som utnyttes i den søndre avdeling av steinknuseriet.

Endelig skal nevnes at det i november 1939 også blev funnet fossiler (*Saxicava*, *Balanus*) i veiskjæringen vest for Grefsen kapell, i leire under en skyllesone som her er 1 1/2—2 m mektig.

Da jernbanen blev bygget gjennem Nydalen i 1898, iakttok W. C. Brøgger en større leiremasse i skjæringen. Efter Brøggers ordvalg, „noget sandblandet blåt ler, moræneler (?) med få og små sten"[1], hvilende på „grovt grus med sten", faller det rimeligst å regne med at det også her dreier sig om en mere eller mindre omeltet leire på sekundært leiested.

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[1] W. C. Brøgger: Nivåforandringer etc., s. 168.

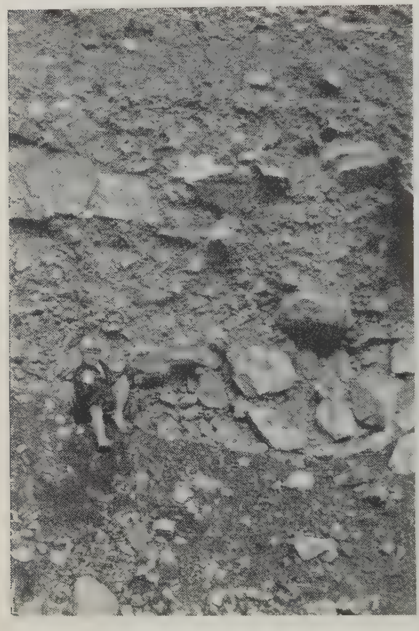

Fig. 6. Rasmasse noen få meter nord for G. Den består av skarpkantet hornfels blandet med vel rundede syenittrullestein. Massen ligger, som det sees, under et horisontalt grusskikt, og dette igjen et stykke under leiren på fig. 4.
F. I. fot. 21/8 1938.

Den fossilførende leire har oprinnelig vært avsatt på innersiden av den nuværende Grefsenmorenen og før Maridalsbreen igjen rykket frem til Grefsen og bygget op morenen der. Hvilket nivå havet nådde til under leirens avsetningstid („Mytilusnivået“ efter Øyens terminologi), kan ikke avgjøres ved Grefsen. Den høieste terrasse der, 217,60 m o. h., markerer jo den marine grense på brefremstøtets tid. I sydskråningen av Holmenkollen og i Skådalen finner man derimot Oslodalens høieste havmerker vel 221 m o. h. eller bortimot fire meter høiere enn brefremstøtets marine grense ved Grefsen. Likeså har Øyen funnet Mytilusfaunaen i Skådalen så høit op som 220 m o. h.[1]

Som konklusjon vil jeg gjenta at all den leire som forekommer i Grefsenmorenen — bortsett fra flekker på overflaten avsatt under den senere hevningstid — efter min opfatning befinner sig i sekundært leie. Den er flyttet dit hvor den nu ligger, og er derved forandret på forskjellig vis: den er omknadd så den nu fremtrer som moreneleire, den kan være skjøvet som flak eller som klumper, noe finnes som mindre boller side om side med rullesteinene i breelvgruset, andre partier er helt utvasket slik at deres materiale nu inngår, sammen med fossilrestene, i leirerike lag i sanden.

Likesom leiren må da også fossilene betraktes som sekundære forekomster. Hverken geologisk eller faunistisk er det noen grunn til å anta at fossilene ligger in situ, der hvor de oprinnelig har levet. Meget taler derimot for det motsatte, og dette gjelder alle de fossilfund som til nu er gjort i Grefsenmorenen.

Herav følger videre at jeg heller ikke er i stand til å se noen tvedeling i morenens opbygning. Det næst øverste finsandlag ved A, som har vært årsak til så mange spekulasjoner, må ansees som resultat av en tilfeldig omlegning av sedimentasjonen foran breranden. Der finnes jo andre steder i morenen, således ved E, nok av fin sand i regelmessige lag, så det er for så vidt ikke noe særlig avstikkende ved forekomsten i det klassiske profil ved A.

Fridtjov Isachsen.

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[1] P. A. Øyen: Portlandia-niveauet ved Skaadalen station. Vid.-selsk. forh. Christiania 1909 no. 6.

KVARTSPORFYR I ÅROS, RØYKEN.

I tilknytning til den diskusjon som for tiden føres om det sydnorske grunnfjells utvikling og særlig om den mulige forekomst av oprinnelige suprakrustalbergarter i Bamleformasjonen, kan det kanskje ha sin interesse å gjøre opmerksom på at det i det lille grunnfjellsområdet på vestsiden av indre Oslofjord finnes en kvartsporfyr som efter sin struktur og sin utbredelse må være en gammel overflatebergart.

Området ligger ikke langt fra Nesodden, hvor suprakrustalbergarter tidligere er påvist av Olaf Anton Broch i en grunnleggende avhandling[1] som naturlig danner utgangspunktet for enhver behandling av grunnfjellet i disse strøk.

Kvartsporfyren forekommer ved Åros like nord for Drammensgranitten og grenser umiddelbart til denne. Av et håndstykke tatt mellem Åroselvens utløp og Drammensgranittens nordgrense, i den bratte veiskjæringen langs fjorden, har Norges geologiske undersøkelse på min anmodning latt fremstille et tynnslip og et mikro-fotografi (fig. 1).

Megaskopisk viser bergarten en tett lysegrå grunnmasse med innsprengte porfyrindivider av rødlig feltspatt optil 1,5—2 mm store, og av mørkegrå kvarts som kan nå samme størrelse. Blandt feltspattindividene sees i håndstykket en enkelt helt idiomorf krystall. Bergarten viser en svak parallellstruktur, som muligens kunde betraktes som nedarvet fra en oprinnelig foliasjon eller flytestruktur; men da parallellstrukturen kan bli tydeligere andre steder i det lille feltet, er det vel rimeligere å regne den for et pressfenomen.

Feltspattindividene viser under mikroskopet uregelmessig form og er noe korrodert mot grunnmassen. All feltspatt både i fenokrystallene og i grunnmassen ligger i lysbrytning under Canadabalsam. De flekkede, uklare porfyrkorn viser på gunstige steder fine albittlameller samt inneslutninger av orthoklas (lavere lysbrytning). Innsprengningene utgjøres altså av antiperthitt; de har små inneslutninger av epidot, inni de større individer også korn av jernerts.

Kvartsindividene er også korrodert og som regel opknust til „aggregater". I enkelte tilfeller finnes antydning til mørtelstruktur i form av en rand av småknuste korn omkring en større kvartskrystall.

Grunnmassen er finkornet og består av kvartskorn i en mellemmasse av feltspatt, sannsynligvis overveiende plagioklas (albitt); kalifeltspatt kunde i hvert fall ikke med sikkerhet påvises. Grunnmassen er jevnkornig og viser tilnærmet Pflaster-struktur. Kornenes diameter ligger overveiende mellem 0,02 og 0,05 mm. Mørke mineraler forekommer sparsomt; der sees et grønt mineral, øiensynlig en noe omvandlet biotitt, med undernormale blålige interferensfarver, og pleochroisme γ' blågrønn $> \alpha'$ gulbrun, målt hos et litt større individ, som også inneholder en inneslutning av formodentlig titanitt. Videre sees små korn av erts, som ofte er knyttet til kloritten (biotitten). Ertsen er svart, opak, et sted dog rødt

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[1] Olaf Anton Broch: Ein suprakrustaler Gneiskomplex auf der Halbinsel Nesodden bei Oslo (Norsk geol. tidsskr., bd. 9, 1927), s. 81—223.

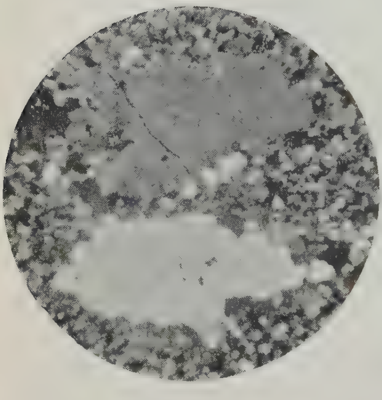

Fig. 1.

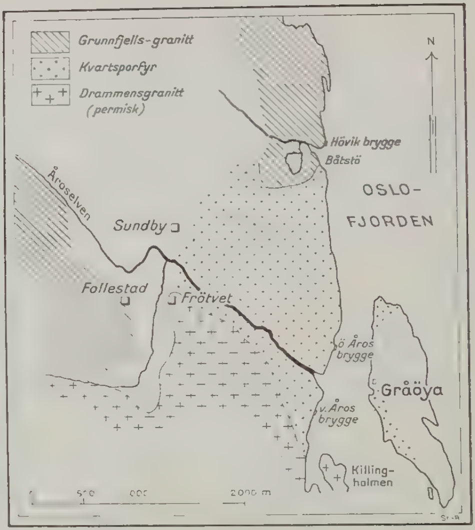

Fig. 2.

Fig. 1. Kvartsporfyr, Åros, Røyken. Fenokrystaller av kvarts (hvit) og feltspatt (grå) i finkornet grunnmasse. Forstørrelse 30 ×. Nicols +. Fot Per Holmsen, N. G. U.

Fig. 2. Kvartsporfyrens utbredelse, skjematisert efter foreløpige iakttagelser av stud. real. Christian Gleditsch høsten 1940.

gjennemskinnelig i kanten, hvilket tyder på jernglans; kanskje der også er magnetitt. Utenom disse korn sees svart støv, formodentlig også erts. Enkelte større ertskorn med lys refleks er antagelig svovelkis. Spredt i grunnmassen finnes bittesmå korn med høi lysbrytning, enkelte viser, når de ikke er for små, epidotens farve og interferensfarver.

Bergarten må efter ovenstående betegnes som en relativt vel bevart kvartsporfyr. Den albittisering bergarten har vært utsatt for, må nærmest antas å være resultatet av hydrothermal påvirkning. Olaf Anton Broch har antydet at antiperthitten på Nesodden[1] særlig synes å forekomme i nærheten av de permiske bruddlinjer og breccier. Professor Tom. Barth som jeg har hatt den fordel å kunne rådføre mig med om dette, antar at albittiseringen har en mere regional karakter.

Som en foreløpig hypotese er det nærliggende å parallellisere kvartsporfyren med Brochs „leptitt" på Nesodden, en finkornet, lysegrå og lite skifrig bergart, som kjemisk slutter sig til de sure ledd av granittfamilien og som Broch antar oprinnelig har vært en liparittisk lava.[2] Godtas denne sammenstilling, bringer påvisningen av kvartsporfyrfeltet en bekreftelse av Brochs slutninger angående leptitten. Det finnes også

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[1] Broch: op. cit., s. 122—123, samt Olaf Anton Broch and Fridtjov Isachsen: The Southern Fault-Line Boundary of Nesodden Peninsula, Oslofjord (Norsk geogr. tidsskr. bd. VII, 1938—39), s. 331—332.

[2] Broch: op. cit., s. 105 ff.

i Nesoddfeltet en porfyrisk varietet, men rent underordnet, og i form av smale bånd slik at dens ekstrusive karakter ikke kunde ansees bevist.[1]

Hvad kvartsporfyrens utbredelse angår, er det viktig å understreke at den ikke optrer i gangform, men finnes som en større masse. Jeg har ved tilfeldige sommerbesøk iakttatt den langs vestsiden av Gråøya fra sportshytten og sydover, langs fastlandsstranden fra Østre Åros brygge til granittgrensen og litt SW for Frøtvet gård (ved det annet „a“ i Sagbakken på rektangelkartet). Høsten 1940 har stud. real. Christian Gleditsch som elev av professor Barth påbegynt en fullstendig kartlegning av dette grunnfjellsområdet og har foreløpig påvist at kvartsporfyren i hvert fall dekker det felt som er angitt på fig. 2. Langs vestsiden av Gråøya løper det amfibolittganger i kvartsporfyren, med retning ca. NNW—SSE. Gleditsch meddeler at han også i den nordlige del av kvartsporfyrfeltet har sett amfibolittganger.

Fridtjov Isachsen.

CONTRIBUTION A L'ÉTUDE DES MÉTASILICATES

Sur la proposition du Dr. V. M. Goldschmidt, professeur de minéralogie à l'Université d'Oslo, j'ai préparé le métasilicate de nickel et de calcium, $NiCaSi_2O_6$, par voie synthétique. Jusqu'ici ce sel n'a pas été préparé; mais le sel de fer analogue existe et suivant les lois émises par M. Goldschmidt sur la relation entre la structure cristalline et les propriétés des ions, leur nombre, leur grandeur et leur faculté de polarisation, il fallait s'attendre à ce qu'un composé ayant la structure d'un diopside puisse être préparé.

Pour la préparation je me suis servi des produits suivants:

Dioxyde de silice préparé d'une olivine, *oxyde de nickel* préparé par calcination du sel $Ni(NO_3)_2 . 6H_2O$ (Kahlbaum, chim. pur) et *carbonate de calcium* (Kahlbaum). Des quantités équivalentes des trois produits furent pulvérisées et soigneusement mélangées puis comprimées en pastilles à une pression de 1 000 kg/cm². Une de ces pastilles fut chauffée à 900° C pendant 5 heures. Le diagramme Debye-Scherrer, pris ensuite, laissait voir les lignes du spectre Röntgen de l'oxyde de Nickel, NiO. La pastille fut chauffée de nouveau pendant 5 heures, cette fois-ci à 1 300° C, mais à cette température elle fondit. Une nouvelle pastille fut chauffée pendant 3 heures à 1 050° C et ensuite 3 heures à 1 200° C. Le diagramme Debye-Scherrer de cette dernière pastille montra une ressemblance très nette avec le diagramme d'un diopside de Piémont.

Pour ces diagrammes Debye-Scherrer je me suis servi du rayonnement de cuivre produit par 36 KV et 10 mA. Le produit à examiner fut mis dans un cylindre en gélatine, diamétre intérieur 0,5 mm, et le chlorure de sodium servit de substance de réglage.

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[1] Broch: op. cit., s. 118—119, om „blastoporfyrisk leptitt“.

Le temps d'exposition fut 3 heures pour le silicate de nickel et de calcium et de 1 heure et demie pour le diopside de Kalb qui est un silicate de magnésium et de calcium.

La ressemblance entre les spectres du diopside de Piémont et du métasilicate de nickel et de calcium que j'ai préparé, ressort nettement du tableau suivant:

Diopside de Piemont	Intensité	$NiCaSi_2O_6$	Intensité
φ°		φ°	
13.35	m	13.53	m
15 05	st	14.88	st
15.85	sv	16.12	sv
17.80	st	17.76	st
19.14	sv	19.36	sv
20.27	m	20.55	m
21.15	m	21.35	m
22.30	m	22 35	m
24.89	sv	24 34	sv
26.08	m	26.09	m
27.39	sv	27 48	sv
28.43	st	28.33	st
30.23	sv	30.18	sv
30.88	sv	30.67	sv
32.83	st	32.87	st
33.18	sv	33.32	sv
35.43	m	35.56	m
36.88	m	36.90	m
37.48	m	37 55	m
40 02	sv	40.59	sv
42.02	sv	42.29	sv
46.02	st	46.03	st
47.06	m	47.27	m
50.04	sv	50.41	sv

Les valeurs hkl qui correspondent aux valeurs de φ furent prises de la publication de B. Warren et W. L. Bragg: The Structure of Diopside $CaMgSi_2O_6$, Z. Krist. 69, 168 (1928).

Pour le calcul des dimensions du réseau cristallin du $NiCaSi_2O_6$ les valeurs suivantes de hkl ont servi:

Diopside de Kalb, USA Warren et Bragg		Diopside de Piémont Gjessing	$NiCaSi_2O_6$ Gjessing
hkl	φ°	φ°	φ°
310	15.12	15.05	14.88
002	17.80	17.80	17.76
440	28 58	28.43	28.33
260	32.94	32.83	32.87
404	37.42	37.48	37.55
750	45.97	46.02	46.03

On aura donc pour le silicate de nickel et de calcium

a_0	b_0	c_0	β°
9.67	8.88	5.25	74° 10′

Le diopside de Kalb donnera de même

9.71	8.89	5.24	74° 10′

et par conséquent:

	a	:	b	:	c
$NiCaSi_2O_6$:	1.089	:	1	:	0.5905
le diopside de Kalb:	1.092	:	1	:	0.5893

Ces resultats montrent que le réseau cristallin du métasilicate de calcium et de nickel a pratiquement les mêmes constantes que celui du $MgCaSi_2O_6$, à quoi il fallait s'attendre, étant donne les valeurs trés rapprochées des diamètres d'ions de nickel et de magnésium.

Je désire exprimer ici mes remerciements à M. Goldschmidt qui m'a permis de faire ce travail au laboratoire du Musée Géologique d'Oslo, qui l'a surveillé et qui m'a donné à chaque moment des conseils précieux.

Leiv Gjessing.

ON RED, FLUORESCENT CALCITE FROM THE FEN AREA NEAR ULEFOSS

During a stay in the Fen area in the first half of September 1940 some large calcite crystals were found in small calcite-bearing veins in the garden east of the office-building at Søve Landbruksskole (Søve School of Agriculture), and in the vibetoite at Nigardskåsa, 50 m north of the top. These crystals display larger and smaller patches of red, the largest being 5 × 2 cm. For a great part the crystals are dull, white, calcite without coloured spots. Together with the red calcite, deeply bluish violet fluorite was encountered. The red colour was remarkably well preserved during heating.

In ultraviolet light the coloured parts showed brightly yellow fluorescence, while the uncoloured parts, like the white crystals, did not fluoresce at all.

The fluorescence may be due to contents of rare earths. To ascertain this, stud. med. Gjessing kindly took some x-ray spectrograms of the calcites. They contained no other heavy metals than iron and manganese, therefore no element likely to cause the fluorescence. To see whether or not the red colour was due to manganese stud. mag. scient. L. Lund took some optical spectrograms of red as well as of white calcite. The manganese contents were practically alike, or slightly larger in the white parts.

The colour and the fluorescence are probably caused by contents of organic matter. A similar phenomenon has been described by H. Haberlandt in calcites from Deutsch-Altenburg on the Danube.[1]

When dissolved in hydrochloric acid, the red calcites from the Fen area gives a faintly yellow solution. The residue dissolved in a compound of ether and acetic acid gives a red solution showing a very marked fluorescence.

The specimens examined come from small and extremely irregular veins and nests, which by the authors are believed to be later hydrothermal deposits. However, they may represent sövite pegmatite.

Norges geologiske undersøkelse,

October 1940.

Henrich Neumann. *Ivan Th. Rosenquist.*

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[1] H. Haberlandt: »Über den Nachweis von Porphyrin und anderen organischen Substanzen im Kalkspat und Aragonit«, Nat. Wiss. *1939*, p. 613.

NORSK GEOLOGISK FORENING.

MØTE FREDAG 31. MAI 1940.

Til stede 11 medlemmer og 15 gjester.

Innvalg:

Medlem nr. 225. Cand. real. Jens A. W. Bugge, Geologisk institutt, Norges tekniske høgskole, Trondheim.
— - 226. Assistentgeolog cand. real. Per Holmsen, Norges geologiske undersøkelse, Oslo.
— - 227. Assistentgeolog mag. scient. Henrich Neumann, Norges geologiske undersøkelse, Oslo.
Efter forslag av Foslie og Størmer.

Foredrag:

Jens Bugge: Trekk av Arendalfeltets geologi.

Arendalfeltet omfatter kartbladene Arendal og Grimstad. Det danner en central del av Kongsberg—Bamleformasjonen, som regnes for å være et av våre eldste grunnfjellsområder.

I Kongsbergfeltet har Carl Bugge påvist sikre effusiver. Han har beskrevet hvorledes metamorfosen og migmatiseringen stiger østover og omtaler innen Håvgruppen flere palingene bergarter. (N. g. u. nr 82, 1917).

På Sørlandet har man hittil ikke funnet primære suprakrustalstrukturer opbevart og det har vært meget diskutert om det i det hele fins dagbergarter her.

En del av de viktigste indisier som taler for at det også i Arendalfeltet forekommer bergarter av suprakrustal oprinnelse omtales i det følgende.

Kvartsitter er svært utbredt i de indre deler av Arendalfeltet. Mot SW kiler de efter hvert ut og nærmere kysten finner man også bare spredte felter av kvartsittiske gneiser blandt de øvrige gneiser og migmatitter.

Arne Bugge har fremhevet den intime forbindelse mellem granitt-kvartsitt og gabbro-kvartsitt, og både han og Olaf Andersen har diskutert muligheten av en magmatisk oprinnelse for kvartsittene.

Nevnte forbindelse er også i Arendalfeltet meget almindelig. Den enkleste forklaring synes å være at kvartsittene hadde større chanse til å bevares mot granitisering der hvor de blev beskyttet av de motstandsdyktige basiske bergarter.

I det hele taler de feltgeologiske undersøkelser for at de kvartsittfelter vi nu finner bare er relikter efter en vidt utbredt kvartsittformasjon, som vanskelig kan forklares hvis man ikke antar en sedimentær oprinnelse. Benytter man den aktualistiske arbeidsmetode, som har vist sig så fruktbar i studiet av grunnfjellet, er det efter vårt nuværende kjennskap til disse bergarter vanskelig å godta en annen forklaring.

I samme retning taler også utbredelsen av krystallinsk kalksten, som optrer i en rekke soner parallell kysten. Kalkstenene er nu bare opbevart i foldenes depresjoner, men det er meget som taler for at de kan ha tilhørt omtrent samme stratigrafiske nivå. De forekommer i nokså intens forbindelse med båndgneisene. I disse må det ansees som sannsynlig at det inngår både sedimenter, effusiver og intrusiver. Avgjørende bevis for effusiver savner man dog, da primære strukturer ikke er opbevart.

Efter dannelsen av disse eldste bergarter har feltet vært utsatt for en meget intens folding med efterfølgende intrusjon av basiske eruptiver (hyperitter).

Av og til finner man relikte strukturer efter de forskjellige metamorfe dybdesoner bergartene har passert før de kom ned i migmatitssonene. Best undersøkt er dette for Arendalittene, en serie noritt-charnockitt bergarter som forekommer mellem Lyngør og Arendal. Bergartene er forbundet både med hensyn til tid og rum, og i kjemisk og mineralogisk henseende viser de så stor likhet og lovmessig variasjon at de må antaes å være genetisk forbundet. I de østlige deler viser de tydelig magmatisk karakter, og de kan efter klassisk opfatning regnes som en egen eruptivstamme.

Foredragsholderen er blitt ledet til å anta at Arendalittene er metasomatiske bergarter dannet ved homogeniserings- og granitiseringsprosesser av et preeksisterende bergartskompleks. Vi befinner oss i Arendal meget nær det nivå hvor magmaet blev dannet.

Det blev med lysbilleder demonstrert hvorledes denne opfatning støttes både av feltgeologiske og mikroskopiske iakttakelser.

Efter sin mineralsammensetning kan Arendalitten henregnes til granulittfacies (til en Arendalitt- eller charnockittsubfacies).

I de surere typer optrer en sterkt pertittisk feltspat som antas å være dannet ved replacement (pertittlamellene en relikter efter plagioklaskorn).

For de mørke mineraler påvistes en diskontinuerlig reaksjonsserie omtrent motsatt den som blev opstilt av N. L. Bowen for magmatisk differentiasjon.

Meget nær samme reakssjonsserie har A. W. Groves påvist for en serie charnockitter fra Uganda, og han har gitt gode beviser for at bergartene er metasomatiske. De viser på mange måter stor likhet med Arendalittene (A. W. Groves. Quart. Journ. etc. XCI, 1935). Det blev også trukket sammenligninger med andre charnockittfelter i Norge hvor lignende forklaringer må ansees for mulig.

I ordskiftet etter foredraget deltok Størmer, Foslie, Barth, C. Bugge og foredragsholderen.

Assistentgeolog Henrich Neumann gav en meddelelse om armenitt, et nytt mineral fra Kongsberggangene. En forelopig notis om mineralet er trykt i Norsk geologisk tidsskrift bd. 19 (h. 4) s. 312. Utførlig beskrivelse blir trykt i næste bind.

I ordskiftet etter meddelelsen deltok Barth og foredragsholderen.

Professor Olaf Holtedahl viste fram sitt nye dypdekart over Norges kyst og gav i tilknytning en kort oversikt over Norges undersjøiske relief.

I det følgende ordskifte deltok Størmer, Foslie, Münster Strøm og foredragsholderen.

MØTE TORSDAG 10. OKTOBER 1940.

Tilstede 23 medlemmer og 16 gjester.

Foredrag:

Harald Bjørlykke: Gull i Finnmark.
Trykt i Norske vi.-selsk. forh. Trondheim 13, 1940, p. 177—180.

I ordskiftet etter foredraget deltok Størmer, Holtedahl, Werenskiold, Henriksen, Münster Strøm, Isachsen, Foslie, A. Holmsen og foredragsholderen.

Trygve Strand: Oversikt over fjellbygningen i Nordre Gudbrandsdalen.

Etter nordre delen av Gudbrandsdalen blir fjellkjeden i innlandsstrøkene i Sør-Norge delt i en sydvestlig og en nordøstlig del. I den sydvestlige delen, med Jotunheimen, har vi de store eruptivmasser av Bergen-Jotun-stammen. Den nordøstlige delen, Trondheimsfeltet, er først og fremst sermerkt av mektige sedimentmasser med kaledoniske intrusivbergarter av Opdalitt—Trondheimitt-stammen. Da grensen mellom de to delene ikke går etter noen skarp linje, blir Nordre Gudbrandsdalen et knuteområde mellom dem, hvor bergarter fra de to deler forekommer sammen.

Foredragsholderen har i sommer lært dette område å kjenne, de feltgeologiske data som ligger til grunn for oversiktskartet er for en meget stor del etter K. O. Bjørlykke (Det centrale Norges fjeldbygning, N. g. u. nr. 39), dessuten har professor W. Werenskiold stillet geologiske manuskriptkarter fra området til disposisjon.

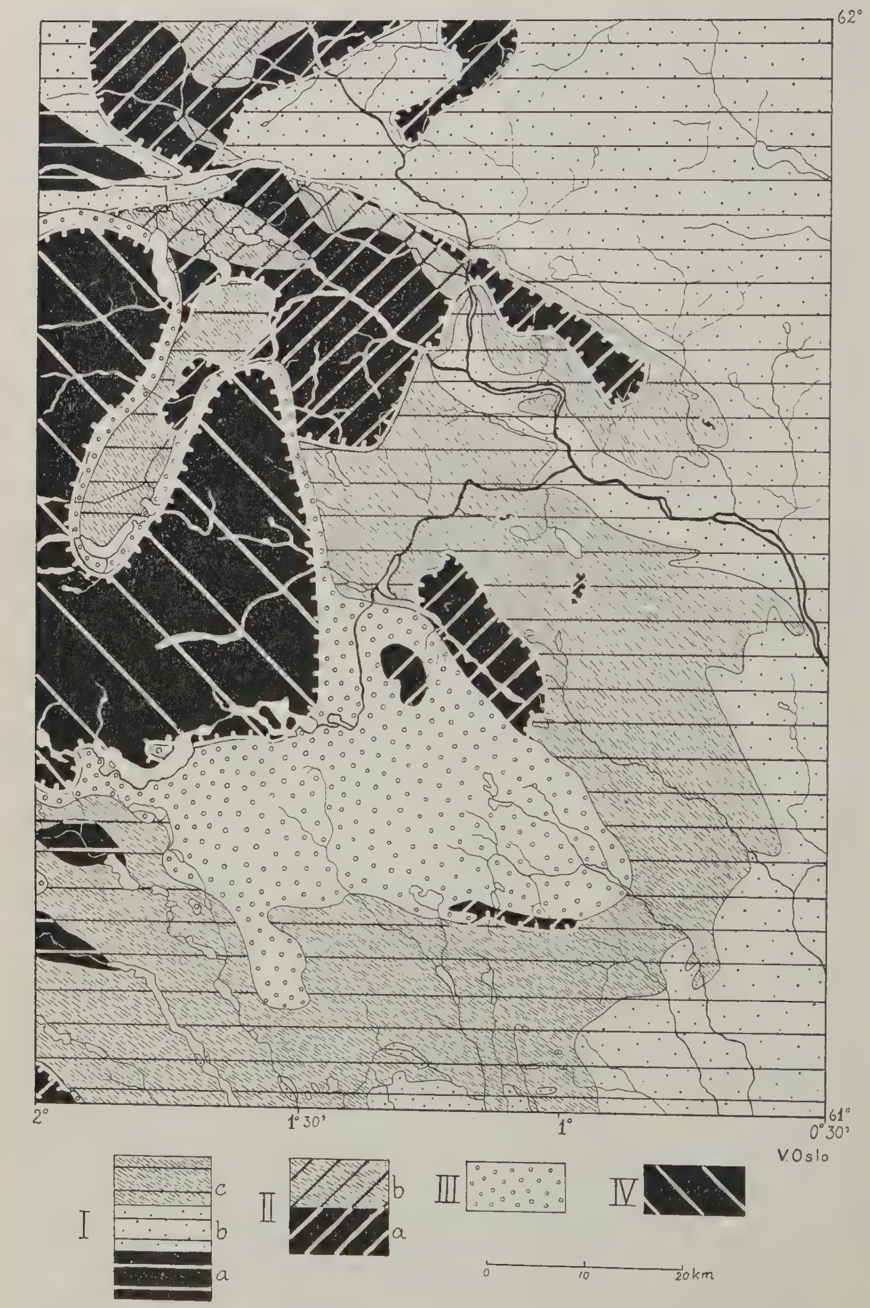
I det området som er tatt med på det meddelte oversiktskart kan bergartene deles i fire vel skilte hovedgrupper.

I a—c. Autoktont grunnfjell, sparagmittformasjonen og kambrisk-ordovisiske leir- og sandbergarter („østlig silur“). I den sydlige delen er avdelingene I b og c for en stor del påviselig alloktone.

II a—b. Det undre store skyvedekke. a. Krystalline bergarter av antatt prekambrisk alder. b. Kambriske? og ordovisiske lag (grønstein, serpentinkonglomerat og leirbergarter)

III. Valdressparagmitt.

IV. Det øvre store skyvedekke, Jotunheimens eruptivbergarter. Linjer med tverhaker er utgåendet av skyveplanene under skyvedekkene II og IV.


62°
61°
2°
1°30'
1°
0°30'
V.Oslo
I
a
b
c
II
a
b
III
IV
0
10
20km

I. Den første og underste avdeling er grunnfjellsunderlaget med påliggende sedimenter av sparagmittsystemet og kambrium-ordovisium. I den siste gruppe er leirbergarter dominerende med innleirete sandstein- og kvartsittlag i noen avdelinger. I sedimentene i denne gruppe mangler kaledoniske intrusivbergarter. I den sydvestlige delen av oversiktskartets område er det påvist overskyvninger innen denne avdeling.

II. Fra syd for Otta til nedre del av Heidal og videre mot sydvest går det ut en markert skyvegrense over skifrene i foregående avdeling. Dette skyveplan ble påvist og kartlagt av K. O. Bjørlykke. Over skyveplanet ligger et kompleks av krystalline bergarter, dels grovkornet og av tydelig eruptiv habitus, av Goldschmidt regnet til Bergen—Jotunstammen, dels så finkornete og utpreget skifrige at de ble regnet til lagrekken av Törnebohm og av Bjørlykke med betegnelsen „grønne skifre". Cand. mag. Tore Gjelsvik har nå begynt på en undersøkelse av disse bergarter, og det skal her derfor ikke sies annet om dem enn at de av foredragsholderen ansees som et prekambrisk kompleks, som danner underlaget for lagrekken i strøket fra omkring Otta stasjon mot nordvest til Lalm. I denne lagrekken inngår følgende led (i overensstemmelse med Bjørlykke):

øverst: Sel-skifer (Sels takskifer)
Serpentinkonglomerat — kleberstein
Konglomerat (Hornblendekonglomerat)
Grønsteinsavdeling
underst: Fyllitter.

Serpentinkonglomeratet inneholder en rik fauna, som etter foreliggende bestemmelse svarer til orthocerkalken (3c) i Oslofeltet. Innen denne lagrekken er det en erosjonsdiskordans, idet Sel-skiferen finnes direkte over gneisunderlag i Tolstadkampen vest for Sel stasjon. Lagrekken er intrudert av eruptiver, for det meste saussurittgabbro, som synes å holde seg på et undre nivå. De finnes alminnelig i grønsteinen, men også i Sel-skiferen i de strøk hvor denne, som ovenfor nevnt, er det underste av lagrekken.

For oppfatningen av det krystalline kompleks som sedimentenes prekambriske underlag has det for tiden ikke noe helt bindende feltgeologisk bevis, som f. eks. sikre basalkonglomerater. Derimot kan de feltgeologiske forhold etter foredragsholderens mening best tolkes ved å anta at sedimentene fra Otta og nordvestover ligger i en synklinal tilgrenset på begge sider av sitt opprinnelige underlag. — På den annen side er det ikke påvist at eruptivbergartene i det underliggende kompleks intruderer lagrekken. Eruptivbergartene i lagrekken (saussurittgabbroer og „hvite granitter") intruderer også de „grønne skifrer" i underlaget og viser seg på flere steder tydelig yngre enn disse. I det underliggende kompleks er det også talrike linseformete intrusjoner av serpentin, delvis omvandlet til kleberstein. Disse intrusjoner finnes derimot ikke i sedimentene, klebersteinene i lagrekken er metamorfe derivater av serpentinkonglomeratet.

Om man vil holde fast på den oppfatning at de krystalline bergarter som her er regnet som det prekambriske underlag for Otta-sedimentene består av sedimenter og eruptivbergarter av kaledonisk cyklus, må de like fullt regnes som alloktone. Ellers blir det uforklarlig at det ikke finnes intrusjoner i lagene under skyveplanet. Den store faciesforskjellen mellom lagene i Otta-synklinalen og lagene under skyveplanet må også tale for at de første har været avleiret under helt andre forhold enn de siste. Serpentinkonglomeratet og de underliggende grønsteiner blir etter de nyere fossilbestemmelser samtidig med Fyllittavdelingen og Bjørlykkes Skifer- og blåkvartsavdeling i lagene under skyveplanet.

Sedimentene i strøket Lemonsjøen—Flatningen (med serpentinkonglomerat) og i fjellstrøket mellom Vågå og Dovre med tilgrensende „grønne skifrer" blir å parallellisere med Otta-sedimentene og deres underlag. Med sistnevnte avdeling må sammenfattes de flak av eruptivbergarter som ligger overskjøvet over kambriske og ordovisiske lag i strøkene sydover fra Otta (Feforkampen, Espedalsstrøket, Røssjøkollene og Grønsennknipa sydvestligst i oversiktskartets område). De oppfattes som spredte erosjonsrester av et sammenhengende dekke.

III. Det neste led er Valdressparagmitten, den kaledoniske flysj. Under den er det en stor erosjonsdiskordans, den ligger derfor på forskjellige led av avdelingene I og II når dens undergrense følges fra det ene området til det annet.

IV. Overskjøvet over Valdres-sparagmitten ligger Jotunheimens store sammenhengende eruptivmassiv.

Hovedtrekkene i fjellbygningen i „knuteområdet" i Nordre Gudbrandsdalen blir således at det over den østlige autoktone eller relativt autoktone lagrekke ligger to skyvedekker av prekambriske krystalline skifrer og eruptivbergarter, i tid og rom skilt ved Valdressparagmitten. Det underste av de to skyvedekker bærer på ryggen en lagrekke som i faciesutvikling stemmer overens med Trondheimsfeltets.

I ordskiftet etter foredraget deltok Størmer, Werenskiold, Chr. Oftedal, Foslie, Holtedahl, Isachsen og foredragsholderen.

MØTE TORSDAG 24. OKTOBER 1940.

Tilstede 17 medlemmer og 19 gjester.

Foredrag:

Olaf Holtedahl og Ivan Rosenqvist: Om fjellbygningen i Opdal—Sunndal-strøket.

O. Holtedahl gav en kort oversikt over resultatene av undersøkelser innen Opdal-bladets område somrene 1938 og 1939, undersøkelser som var utført i direkte fortsettelse av dem som det var redegjort for i foredraget i foreningen 17. mars 1938 (sml. avhandlingen i N. g. t., b. 18, h. 1, 1938). Arbeidet blev i 1939 utført for N. g. u. og med stud. real. Hans Holtedahl som assistent. Foredraget illustrertes med en geologisk kartplansje og lysbilleder, likesom et stort antall bergartsstykker var lagt frem på møtet.

Særlig interessante forhold var funnet i den nord-vestlige del av kartbladet. Den sterkt metamorfe sandstenslagrekke som var angitt på kartskissen fra 1938 i trakten Storli—Okla og som var antatt å representere sparagmittformasjonen, falt i to deler, en øvre, hvis hovedbergart kunde betegnes som en sparagmitt-gneis, og en undre som var av utpreget kvartsittisk karakter. Under denne kvartsitt forekommer en for det meste temmelig massiv, grov biotitt-rik granitt som efter sin forekomst i Nonshøtrakten kan kalles Nonshøgranitten. Bergarten er tildels porfyrisk, og lokalt, særlig nær under kvartsitten, kan den være adskillig skifrig. I vestskråningen av Okla hvor bergmassen har en invertert karakter med kvartsitten fallende (mot NV) inn under granitten, var der funnet, langs grensen, et uhyre sterkt omdannet konglomerat, med kvartsrullesten. Dette konglomerat må opfattes som sparagmitt-formasjonens bunnkonglomerat og granitten følgelig som grunnfjell. Forholdene minnet adskillig om dem i Trollhettastrøket i Trollheimen, hvor man også har et stort område med massiv granitt (dog av en helt annen type) under kvartsitt. Av særlig betydning for opfatningen om fjellbygningens alminnelige karakter var forholdene i Kringlehø som med sin nordre del ligger litt utenfor kart-området. Her kiler den over sparagmitt-gneisen liggende (serpentin-førende) hornblendeskifer — som må antas å representere en lav del av Trondheimslagrekken — ut mot vest og samtidig sees sparagmitt-gneisen (som tildels inneholder øiegneis-soner) å bøie helt rundt og legge sig over skiferkomplekset. Her er en typisk overfoldning, med svevende lagstilling, altså et nytt og særlig klart eksempel på dekke-strukturen som alt i 1938 var hevdet å være typisk for store deler av kart-området. Ovenpå den inverte sparagmitt i Kringlehø kommer tynne (utklemte) partier av kvartsitt og derover en sterkt presset granitt som uten tvil representerer et overfoldet parti av Nonshø-granitt. De mørke, rundaktige inneslutninger som er karakteristisk for denne granitt i „Nonshø-antiklinalen“ og i Okla-området, er i Kringlehø-bergarten presset ut til flate partier. Lange tynne kvartsittpartier i sparagmitt-gneisen i Kringlehøs sydvestre del forteller også om sterkt utklemte overfoldninger. I strøket vest for Tovatn, i karthjørnet, stryker så de nevnte bergarter mot V og SV, utover mot Sunndals—Innerdalstraktene.

Der omtaltes forhold også fra en rekke andre områder av kartbladet, bl. a. fra Drivdalen ved Åmotsdalen og fra Sunndals-området like nedenfor Gjøra hvor (sparagmitt-) hellesten, kvartsitt og hornblendeskifer (med kalkstensinnleiringer) stryker tversover dalen og fra høitliggende fjellpartier var sett å fortsette langt sydvestover.

I sydøst for det nevnte område ved Gjøra kommer en lys (biotittførende) gneisgranitt under hellebergartene (og øiegneis), i Grytvasshaug—Kjerringa-partiet. Denne „bunngneis“ har en langt tydeligere parallellstruktur enn granitten i Nonshø-området. Inne i massen i Kjerringaområdet forekommer en lagrekke av en muskovitt-rik hellestens-lignende bergart, med meget svakt østlig fall. Muligens har vi her en fortsettelse av den av Rosenqvist påviste steiltstående hellestens-masse i sydøst ved Storvatn, men med nesten flat lagstilling. Fra „Hornet" -fjellpartiet, nordvest for Ålbu, anførtes endel nye iakttakelser bl. a. forekomst av meget vakker primær skråskiktning i tykkbenket sparagmitt-gneis, videre forekomsten av en rekke ganger som ved å gjennemsette det omgivende sparagmitt-bergs folder, samtidig som de selv tildels viser en sterk sekundær skifrighet (foruten en petrografisk omdannelse), tilkjennegir at de er brutt frem efter deformasjonstidens begynnelse, men før dens avslutning. Med hensyn til den i forrige foredrag fremsatte formodning at Hornets øvre sparagmitt-øiegneis-masse representerte et folde-dekke, så syntes Rosenqvists påvisning av at den underliggende hornblendeskifersone forsvinner i fjellmassen syd for Driva (S og SV for Tilset), og at den over- og underliggende sparagmitt-sone her går sammen, å være en sterk støtte for riktigheten av nevnte opfatning. Man får en parallell til Kringlehø-inversjonen, bare i en uhyre meget større målestokk.

Det var i diskusjonen etter forrige foredrag, og også ellers fra forskjellig hold, gjort gjeldene at den mulighet forelå at de sparagmitt-kvartsitt bergarter det dreiet sig om i det undersøkte område og som efter foredragsholderens, alt i 1936 fremsatte, mening måtte formodes å optre også i vestligere strøk av det område som er betegnet som grunnfjell på de geologiske oversiktskarter, at disse bergarter ikke var av eokambrisk alder, men tilhørte Telemarksformasjonen. Det blev i foredraget påny fremhevet hvordan de generelle geologiske forhold rent direkte taler til fordel for at det dreier sig om sparagmitt-formasjonen bl. a. fordi det jo sydøst for Trondheims-mulden dukker op veldige masser av eokambrisk sparagmitt og kvartsitt og at det allerede av den grunn fremstiller sig som det eneste naturlige at de metamorfe sandstens-sedimenter som optrer konkordant under Trondheims-skifer også i nordvest, er av eokambrisk alder. Da det av K. O. Bjørlykkes iakttagelser fra Høvring-traktene syntes å fremgå at her forelå en fjellbygning som minnet meget om den man finner like vest for de typiske og forholdsvis lite metamorfe Trondheims-skifre i Opdal-strøket, hadde foredragsholderen i februar 1939 sett litt på forholdene ved Høvringen og innsamlet endel bergarter (av hvilke en serie blev fremlagt). Man har i dette strøk under de lite omdannete Trondheims-skifre et øvre (nordvestlig) sparagmitt-parti som ved en sone av hornblendeskifer med kalkstenlag, serpentin og gabbroide bergarter m. v., er skilt fra de svære sparagmitt-massene lenger sydøstover. Den nevnte hornblendeskifer-sone kan tenkes å svare til hornblendeskifrene mellem øvre og undre hellestensserie i Ålbutrakten i Opdal. Typisk for Høvringen er også den alminnelige forekomst av øiegneis, i eller i nær tilknytning til sparagmittmassene like over skifersonen.

Til slutt omtaltes forekomsten av betydelige kvartsittmasser langt ut mot fjordområdet i Sunnmøre, nemlig straks øst for Grotli, masser som på samme måte som de forskjellige som der ved forrige foredrag var gjort opmerksom på, meget naturlig kunde tenkes å representere eokambrium, i og med at det måtte fastslåes som et faktum at eokambriske sedimenter stryker sydvestover fra Opdal-bladets vestligste del. Det henvistes endelig til Foslies anførsel om forekomsten av kromførende serpentinmasser i det romsdalske „grunnfjell“ og hans uttalelse om muligheten av at disse kan stå i forbindelse med sekundære kaledoniske foldningsgrøfter.

Rosenqvists foredrag vil bli trykt som avhandling i bd. 21.

I ordskiftet efter foredragene deltok Størmer Strand, Barth og foredragsholderen.

MØTE TORSDAG 7. NOVEMBER 1940.

Tilstede 19 medlemmer og 12 gjester.

Innvalg:

Medlem nr. 228, cand. mag. H. C. HANSEN, Midtstua, Kihlsbakken, Kambo ved Moss.

Etter forslag av Rosendahl og Størmer.

Foredrag:

TH. VOGT: Bidrag til Spitsbergen-devonens geologi og stratigrafi.

A. HEINTZ: Oversikt over fiskefaunaene i Spitsbergens downtonsk-devoniske lagrekker.

SVEN FØYN: Stratigrafiske og geologiske undersøkelser av devonformasjonen på Spitsbergen utført på den engelsk—norsk—svenske Spitsbergen-ekspedisjon 1939.

O. A. Høeg ga i tilknyting til foredragene en kort oversikt over Spitsbergens devoniske floraer.

Vogts foredrag vil bli trykt som avhandling i tidsskriftet; Heintz's og Føyns i Skrifter om Svalbard og Ishavet.

I ordskiftet etter foredragene deltok Størmer, Orvin, Horn, Holtedahl, Vogt og Føyn.